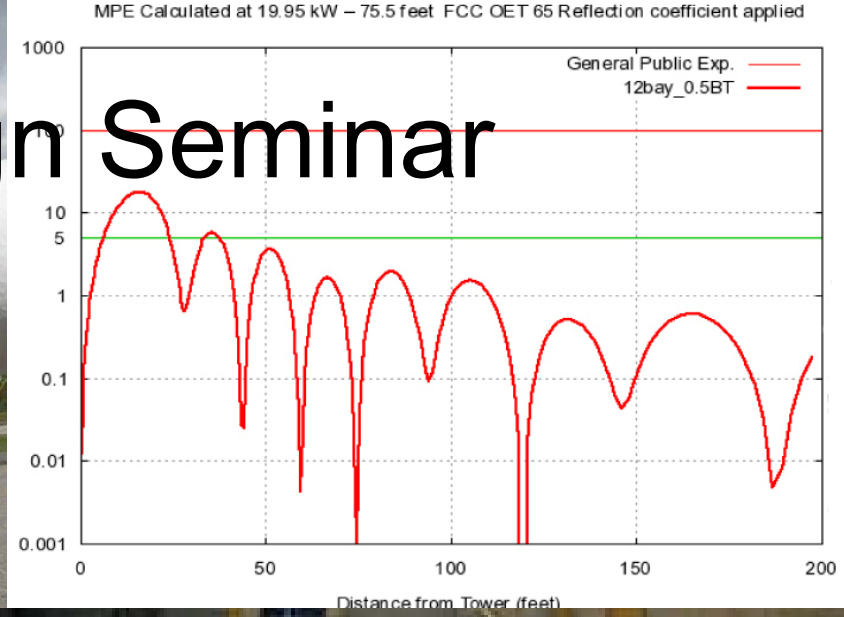


Antenna Design Seminar



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What we are going to cover

This seminar will cover the design concepts of a variety of broadcast antennas that relates to the design of TV and FM antennas.

We will first look at antenna directivity and azimuth pattern performance.

The second half of the seminar will look at the elevation patterns of antennas, and the effects of these patterns on RFR levels.



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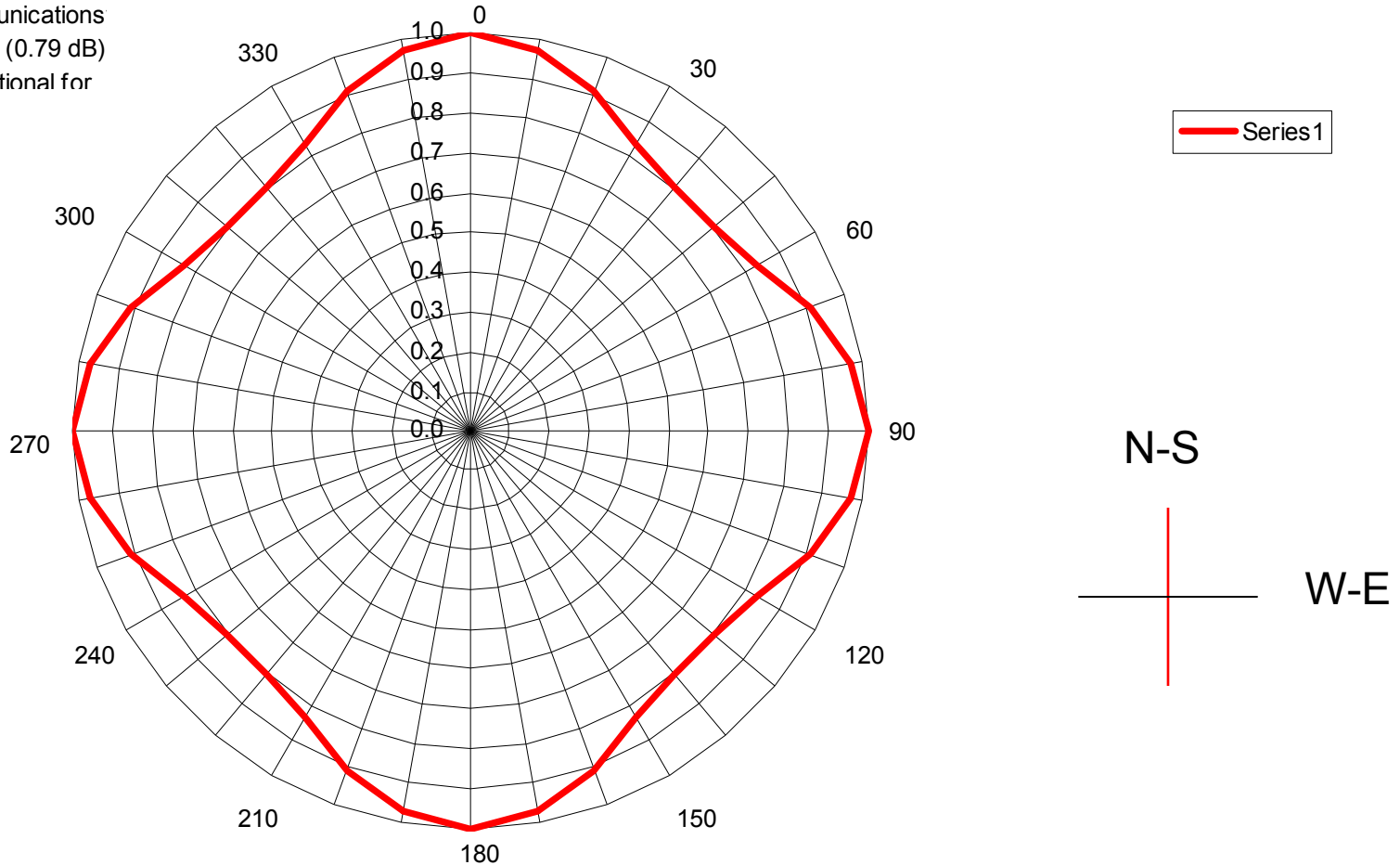
Azimuth Patterns

The azimuth pattern is the horizontal directivity of the antenna. For broadcast applications we usually think of omnidirectional or directional patterns. Omnidirectional patterns can have as much as ± 2 dB directivity, while a directional azimuth pattern can have up to a 30 dB ratio between the peak “maxima” and the smallest “minima”



Typical Omni-directional Patterns

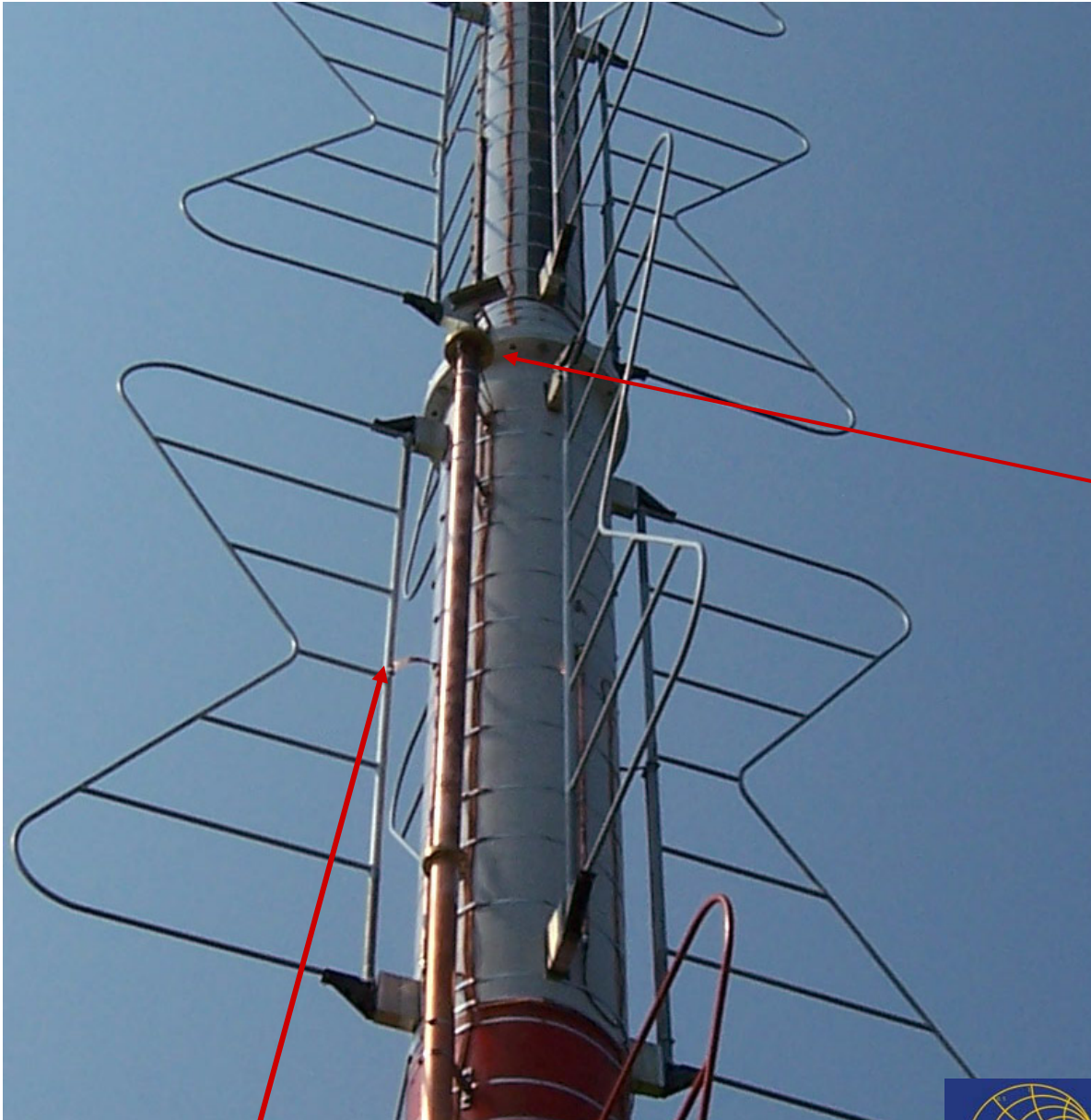
Micronetixx Communications
Azimuth Gain 1.20 (0.79 dB)
Pattern: Omnidirectional for



VHF Batwing Antenna



VHF Batwing



Power Divider

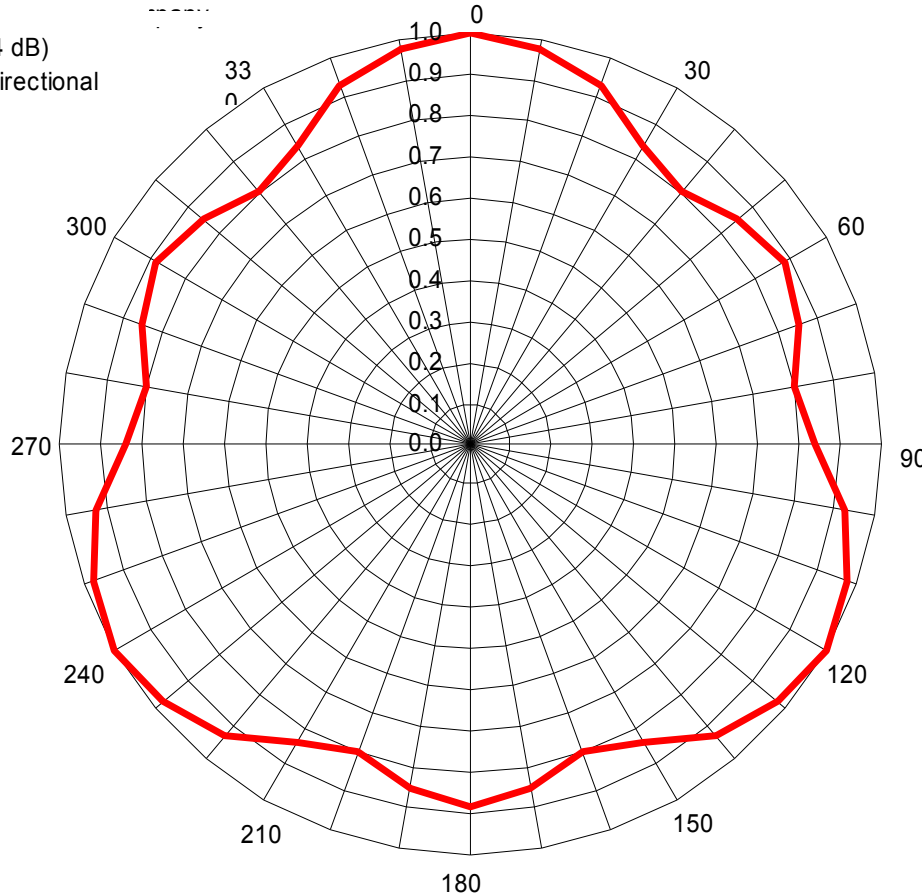
Feed point



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Typical Omni-directional Patterns

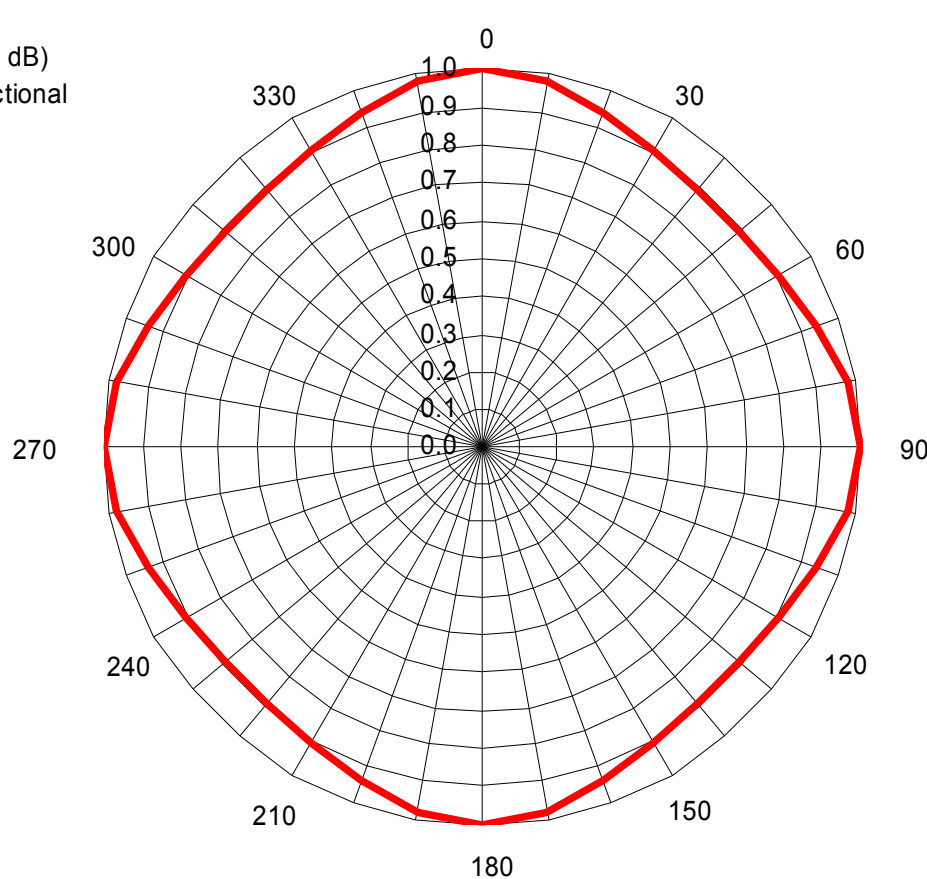
Azimuth Gain 1.3 (1.14 dB)
Pattern: 3 Panel Omnidirectional



3 Panel VHF/FM Omni-directional Azimuth pattern with panels at 120 degrees and reflectors touching.

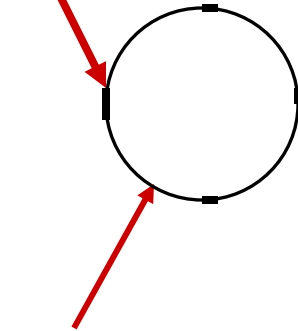
Typical Omni-directional Patterns

∩
Azimuth Gain 1.11 (0.45 dB)
Pattern: 4 Slot Omnidirectional



Series1

Slots – 4 places

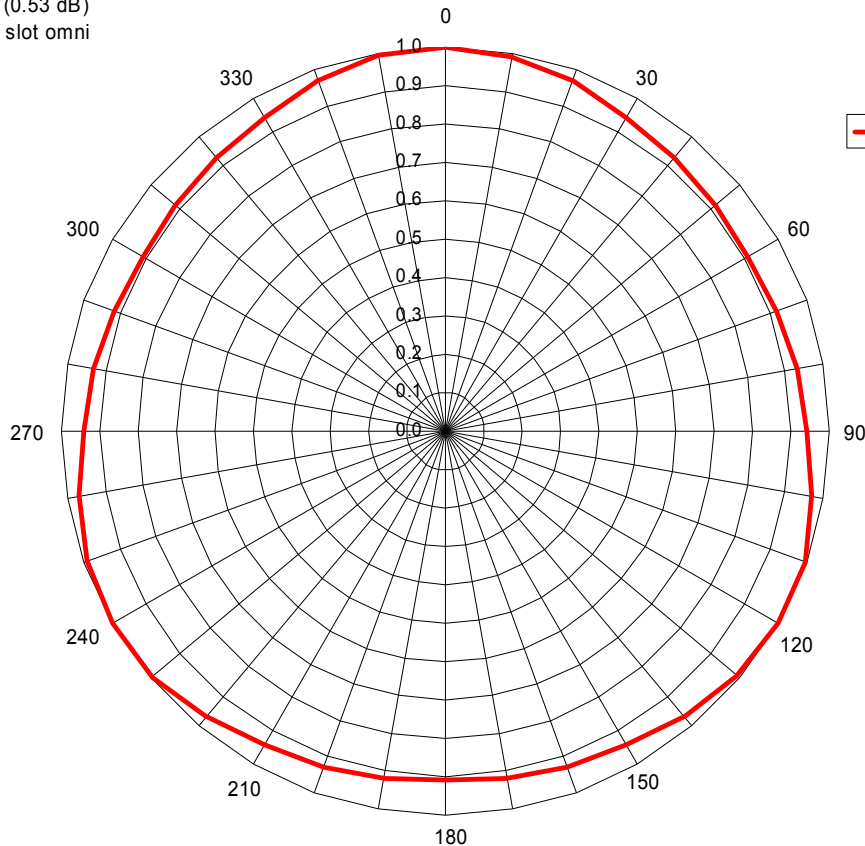


Pylon diameter of
10 to 12 inches for
UHF – 18 to 22
inches for VHF

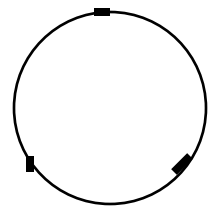
4 Slot Omni-Directional VHF or
UHF Slot Antenna

Typical Omni-directional Patterns

Azimuth Gain=1.13 (0.53 dB)
Azimuth Pattern= 3 slot omni



O3 UHF Azimuth Pattern



3 Slots per bay –
120 degrees apart

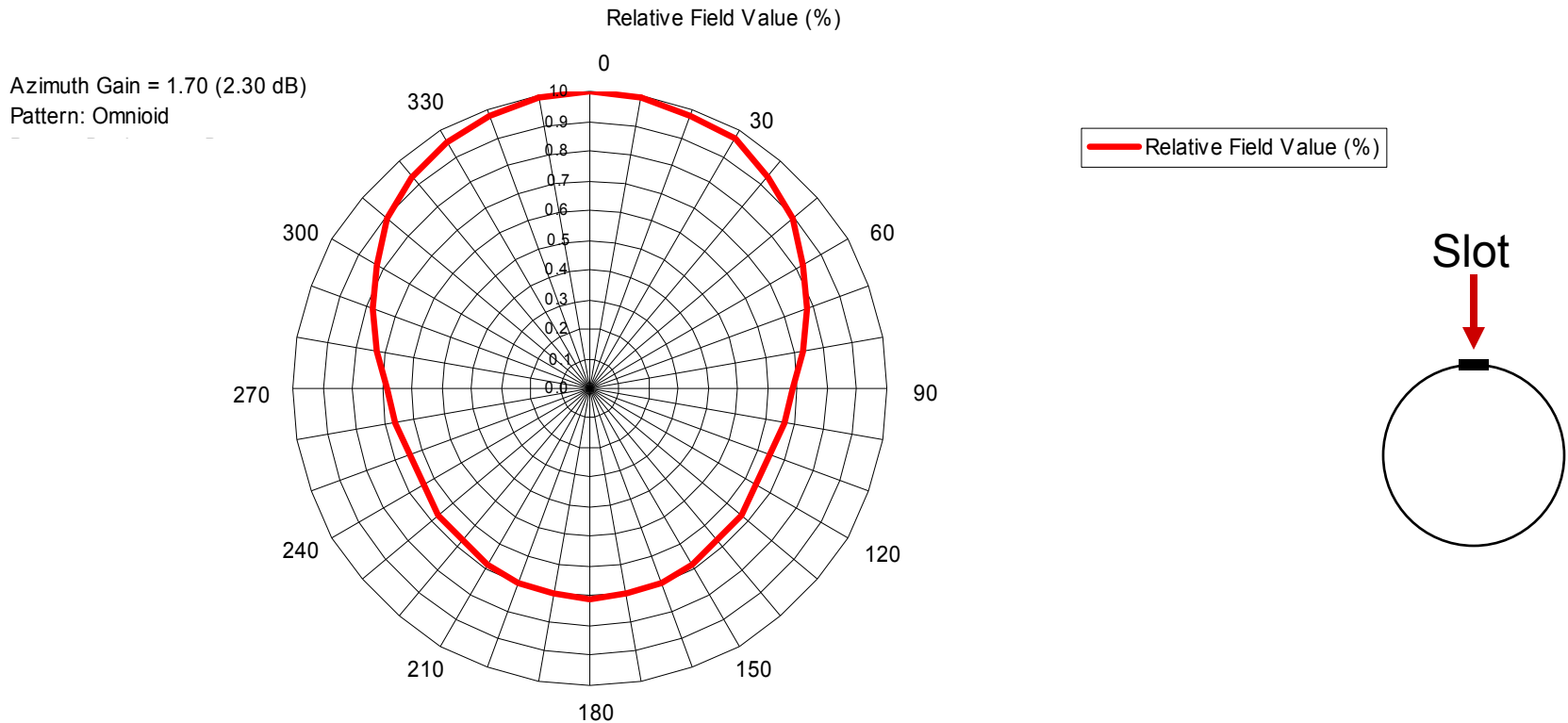
3 Slot Omni-directional VHF or UHF slot antenna. A 6 inch pylon is used for UHF, a 14 to 20 inch for VHF





A 3 slot around Omni-directional VHF Pylon antenna on channel 13

Typical Omni-directional Patterns



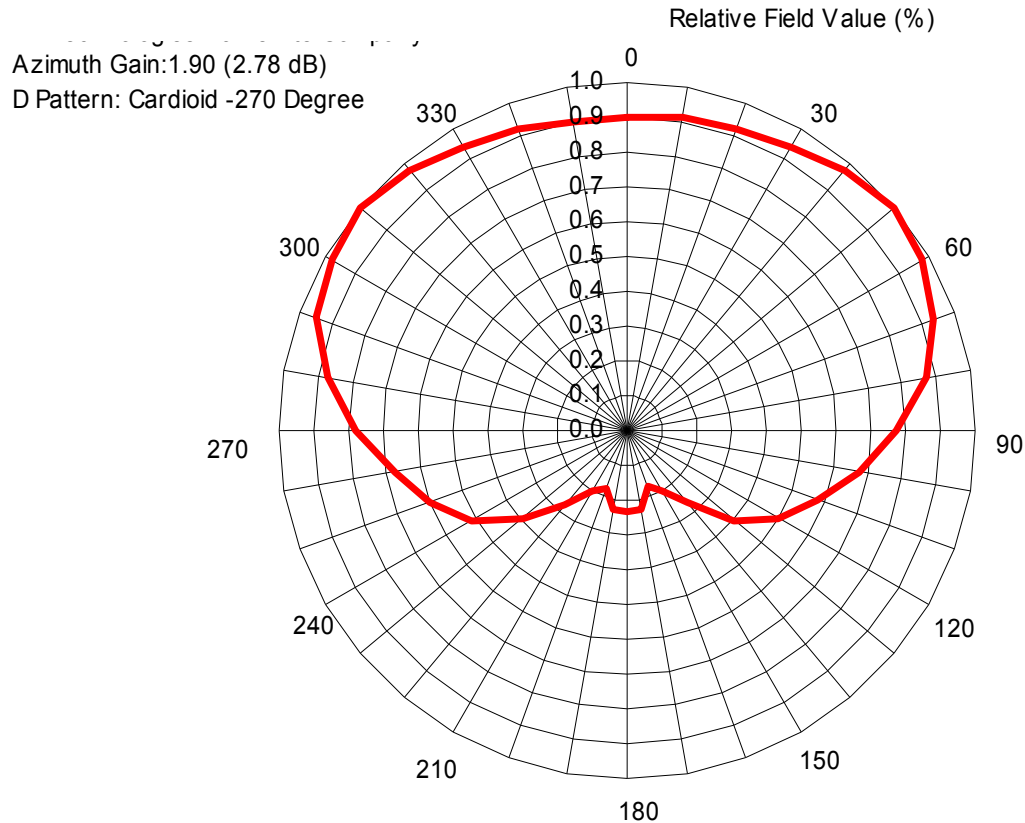
This pattern is often used as an omni-directional pattern, It's the easiest to build antenna with one slot per bay and no parasitic elements. For UHF a 3 to 4 inch pylon is used, for VHF a 10 to 12 inch pylon is used.

Directional Azimuth Patterns

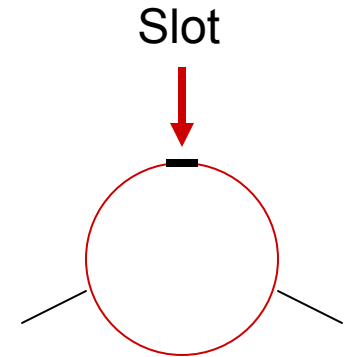
Directional azimuth patterns are accomplished by adding parasitics to the antenna or by using uneven power division to the antenna elements or slots.

For slot antennas parasitics are almost always used, except in multi slot per bay antenna designs. Panel and Batwing antenna use power division to build patterns.

Basic Directional Patterns

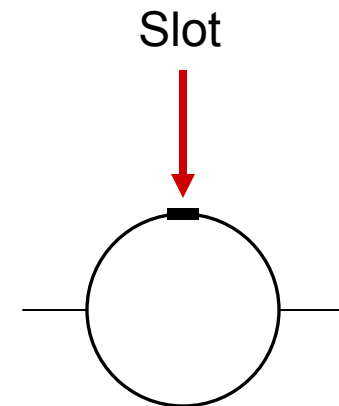
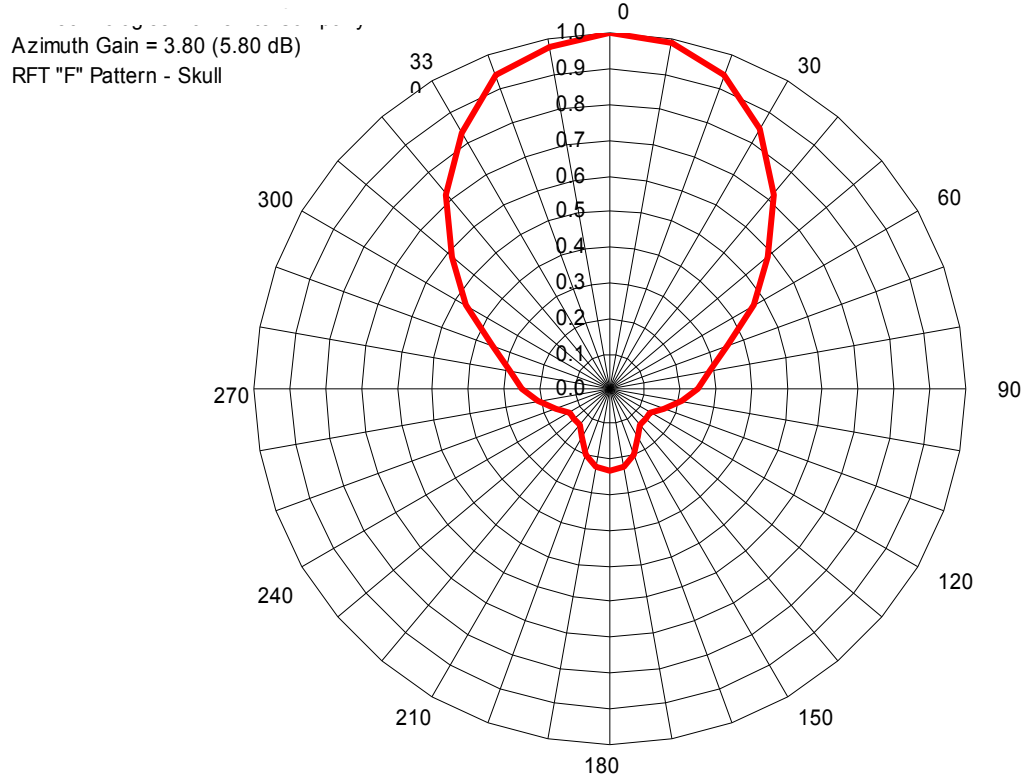


Relative Field Value (%)



This is a broad cardioid pattern and is formed with a single slot and two angled wings. The length of the wings is frequency dependent.

Basic Directional Patterns



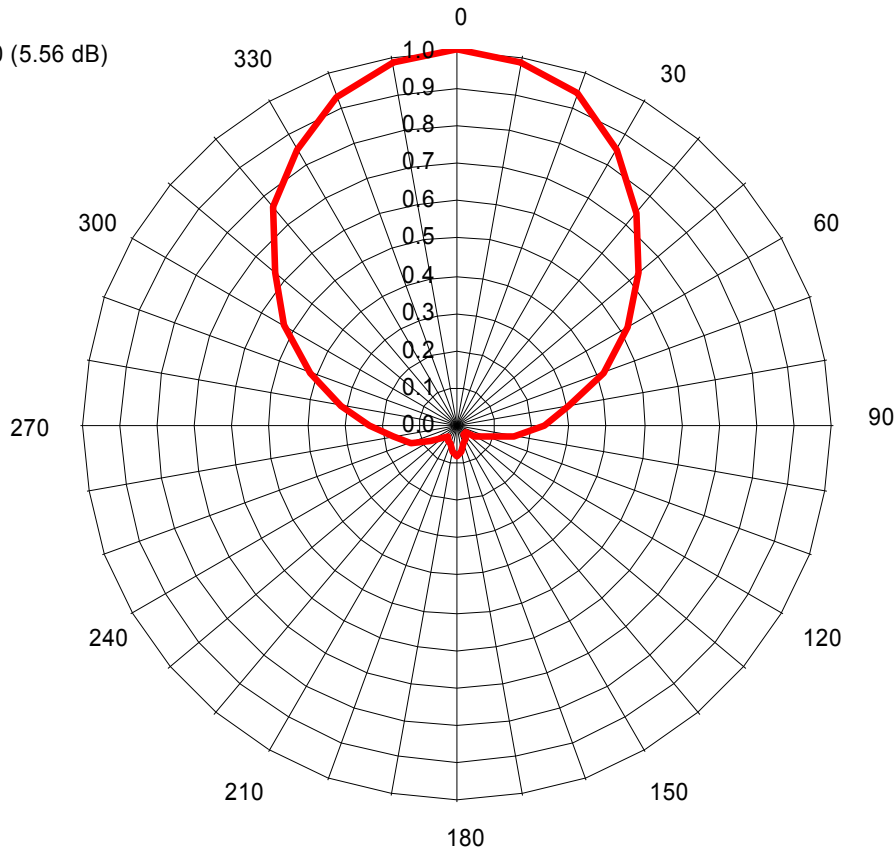
A narrower cardioid or skull pattern that is formed with a single slot and two wings at 180 degrees. The wings are frequency dependent. The next slide shows a channel 20 antenna with this pattern.



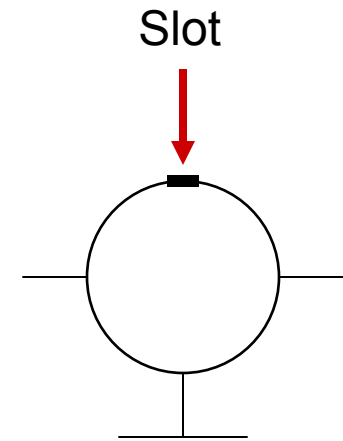
Here is an example of the skull pattern antenna from the previous slide. These are two 7 bay halves to form a 14 bay center fed antenna,

Basic Directional Patterns

Azimuth Gain = 3.60 (5.56 dB)
Pattern: G
Skull-Reduced Rear



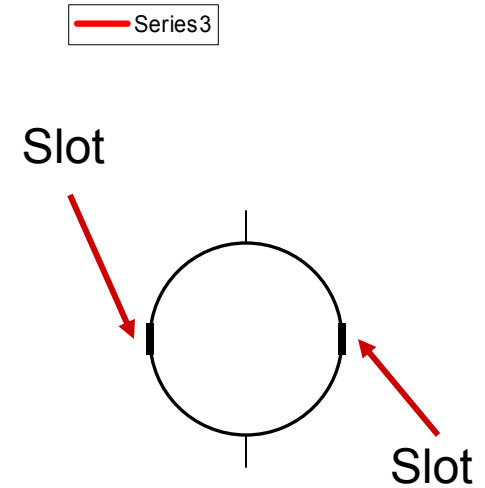
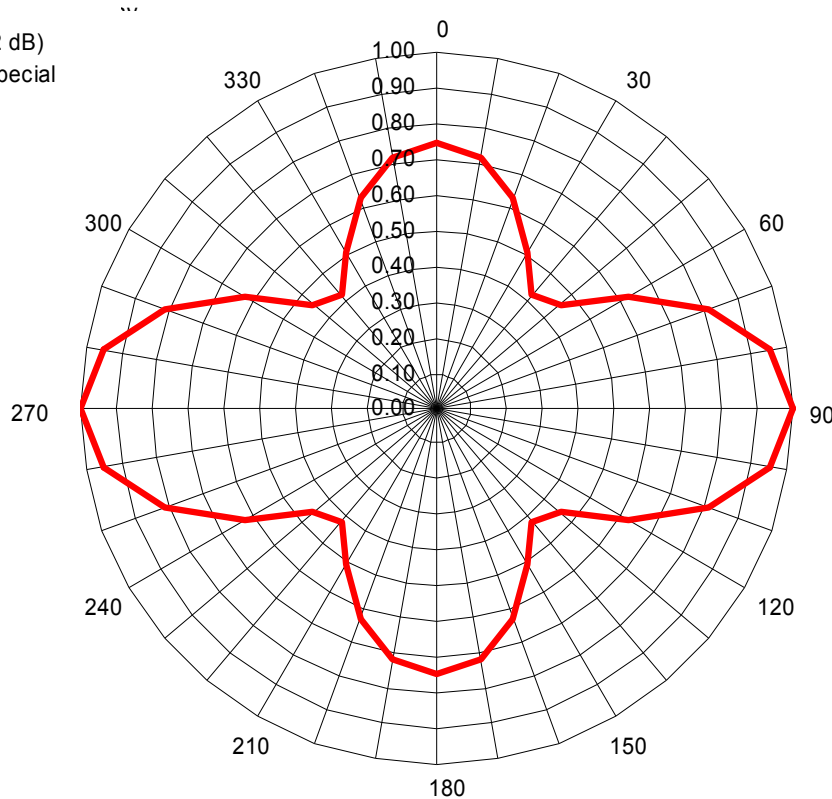
Series 1



A reduced cardioid with a higher front to back ratio. The reduced rear pattern uses a second parasitic behind the pylon to reduce the radiation to the rear.

Basic Directional Patterns

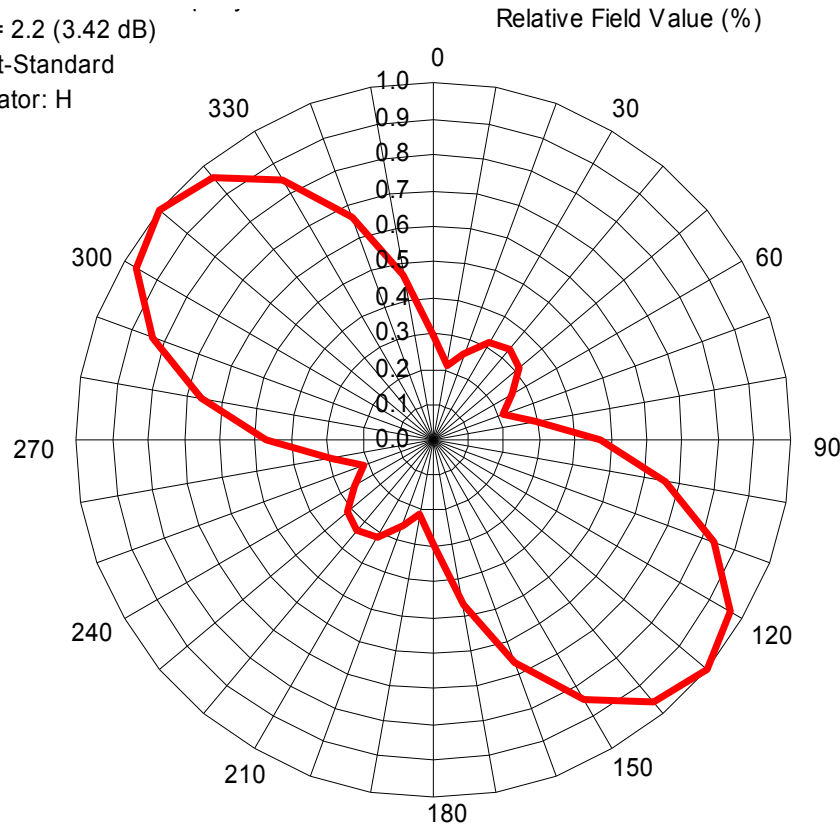
Azimuth Gain: 2.1 (3.22 dB)
Pattern: 5771 Peanut Special



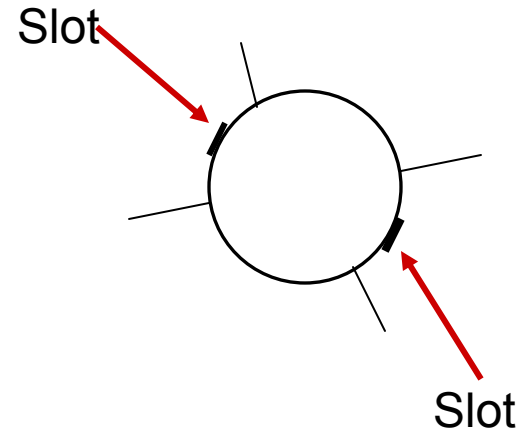
This peanut pattern uses two slots per bay, 180 degrees from each other. Two small wings help form the two smaller maximas.

Basic Directional Patterns

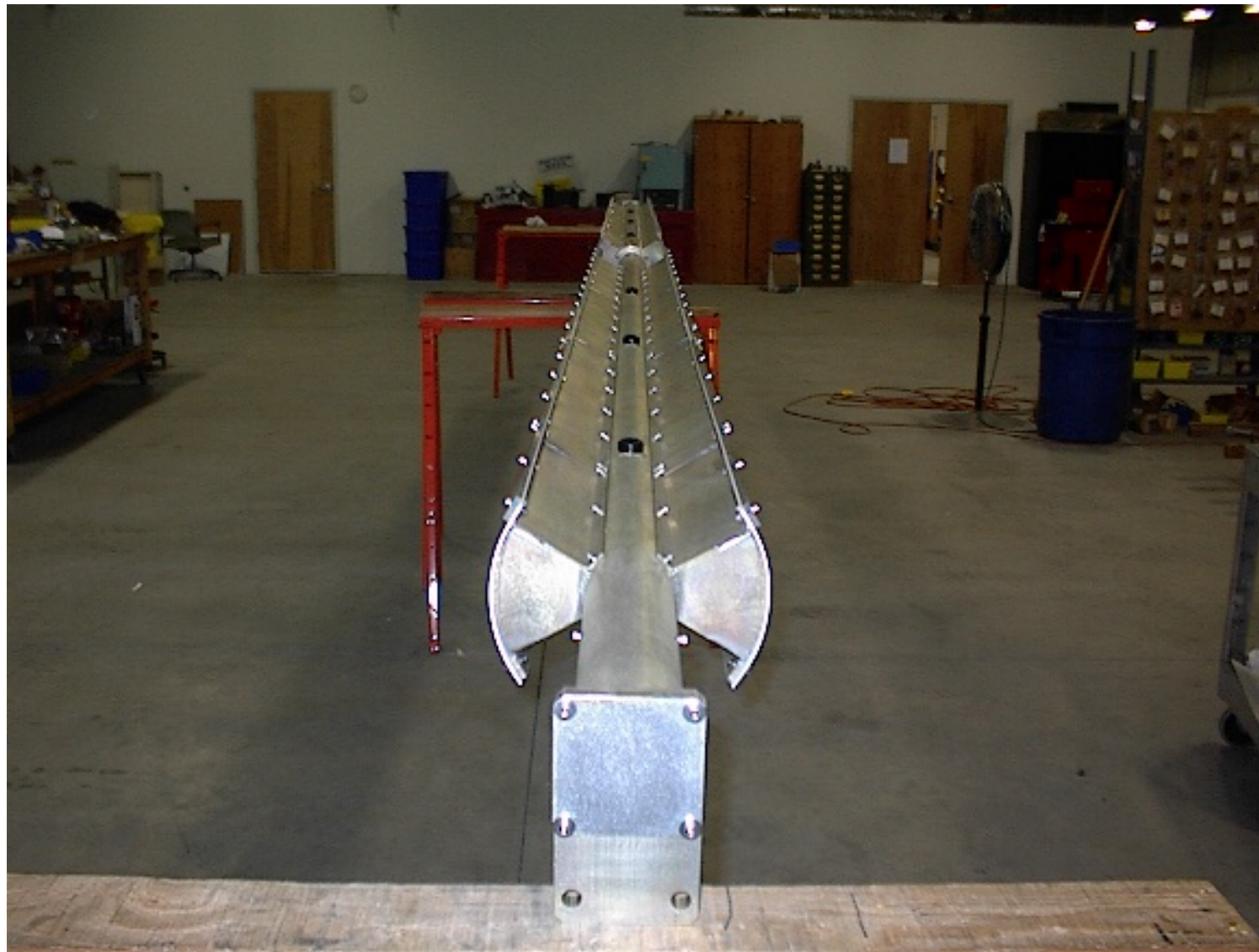
Azimuth Gain = 2.2 (3.42 dB)
Pattern: Peanut-Standard
Pattern Designator: H



Relative Field Value (%)



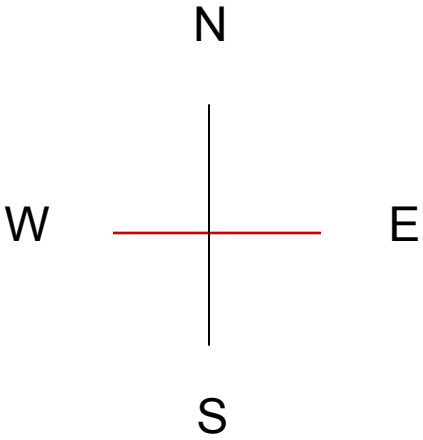
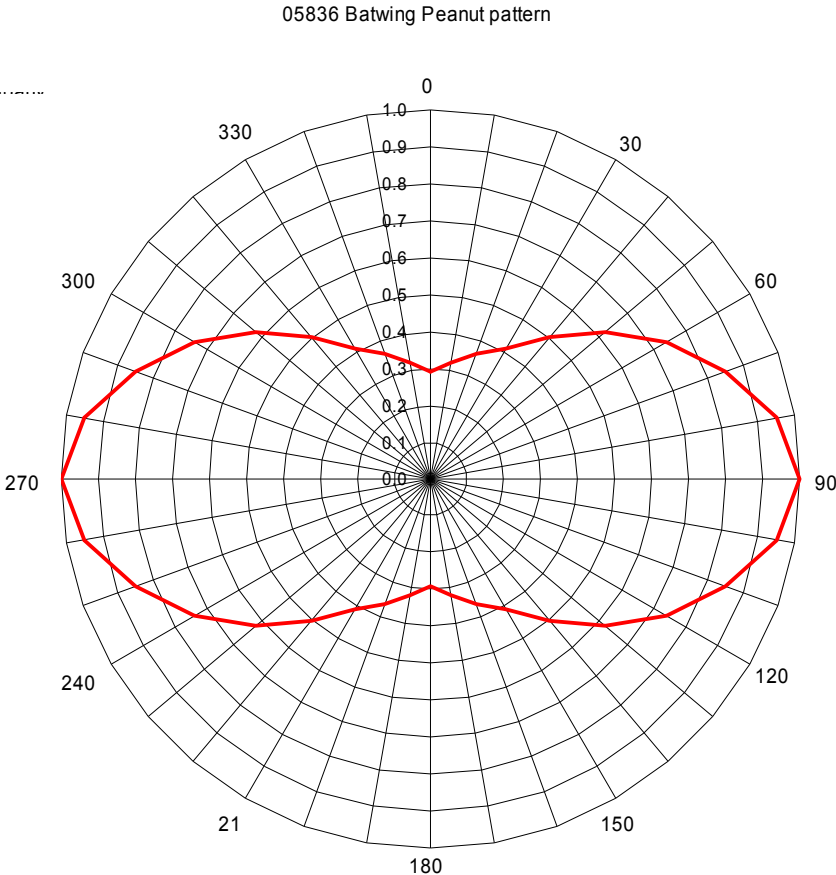
This peanut pattern uses two opposing slots per bay with two sets of wings to form the main beams. The wings are very frequency sensitive with this pattern.



The previous slide had a plot of a peanut pattern antenna. Here is the end of the antenna.

Special Directional Patterns

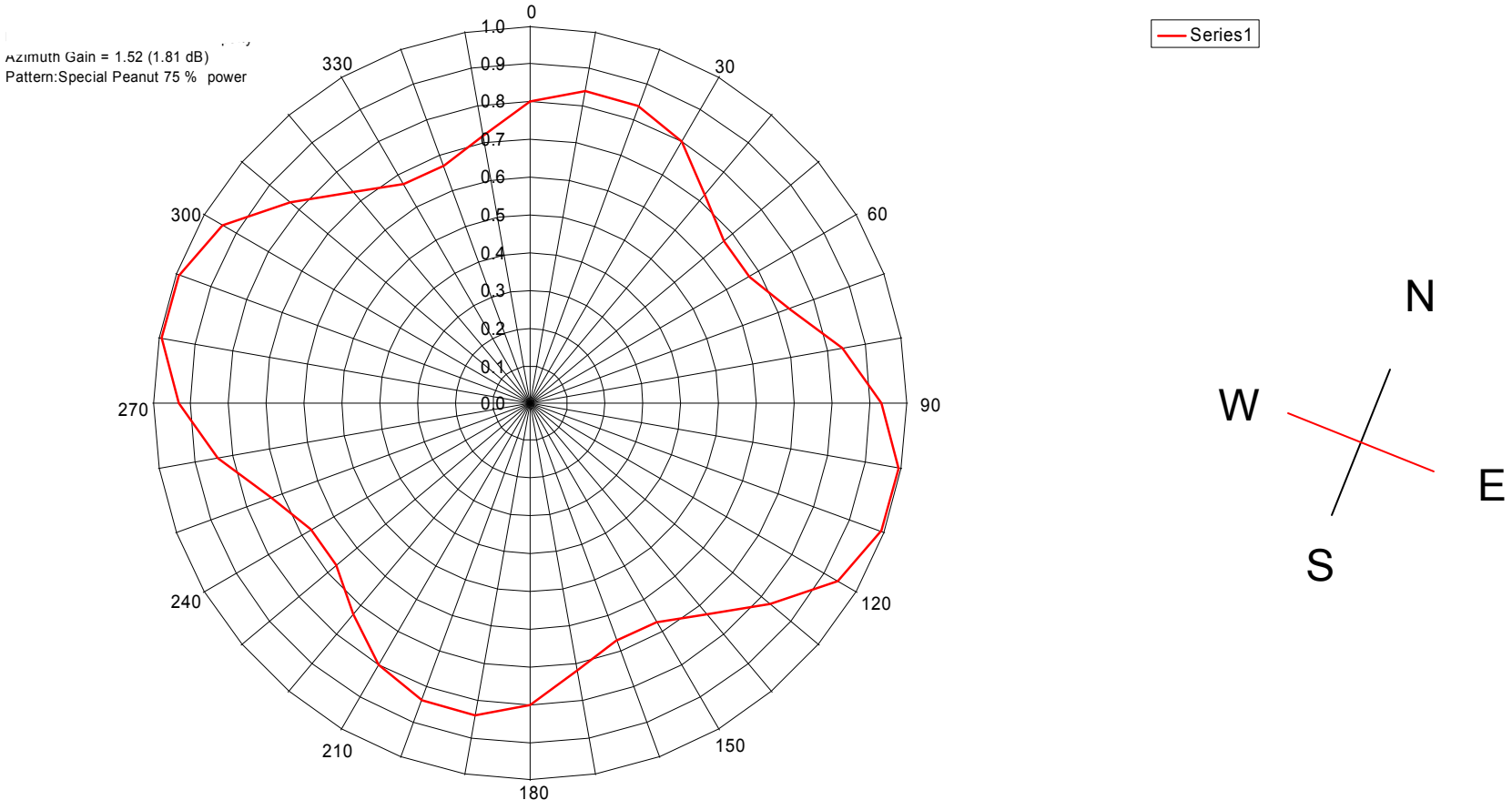
Special Peanut Pattern Batwing
Azimuth Gain 2.25 (3.52 dB)



Special Batwing peanut pattern. East - West elements are fed with only 25% power



Special Directional Patterns



This antenna has a 75% power ratio to the East and West elements to make a fatter peanut pattern



Elevation Patterns

The vertical pattern of an antenna and how well it's focused on your viewers determines how well your station fare in the marketplace. In 99% of cases your viewers are a few degrees below the horizon (except for a part of Anchorage, Alaska). Most of the distant viewers (2 to 60 miles away) are between -1 and -4 degrees below the horizon. In markets with high mountain transmitter sites and close in population (El Paso, Salt Lake City, Vancouver) viewers can easily be between -4 and -10 degrees below the horizon.

A very broad low gain pattern can take up a lot of transmitter power to make the licensed ERP, while a high gain antenna can shoot it's main lobe over nearby potential viewers.

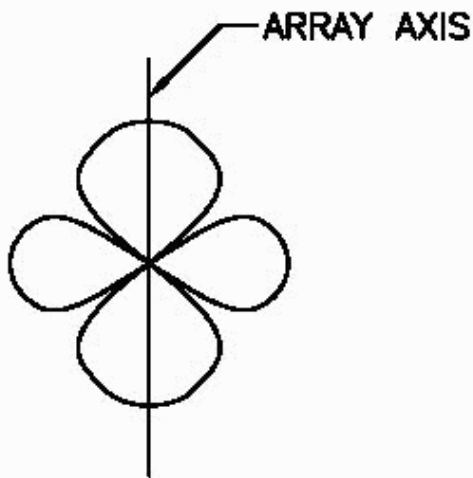
Let's look at some basics of antenna elevation patterns.



Antenna Elevation Patterns

ARRAY RADIATION PATTERN

Let's take a look at arrays and array radiation patterns a little more closely. To do this, it's very helpful to consider a simple linear array of two elemental radiators, each transmitting their signals in all directions equally, as shown in Figure 1 below, (the two elemental radiators are not distinctly shown):



These two theoretical point source radiators are commonly called isotropic elemental radiators. If these two elements are uniformly excited, (with the same magnitude and the same phase relative to one another), and are spaced at one full wavelength on center, the array pattern from these elemental radiators peaks to a maximum at zero degrees elevation angle, which is exactly broadside to the array. This is usually the desired result, since vertically placed television broadcast antennas literally fire their signals broadside toward their viewing audiences. However, another field maximum also occurs. This field maximum lies exactly along the axis if the array, above and below the antenna as shown.

Figure 1

Antenna Elevation Patterns

ARRAY RADIATION PATTERN

With practical television broadcast antennas, the individual elemental radiators do not transmit their signals in an isotropic fashion, or in all directions equally. These practical elements radiate their signals broadside much more strongly as shown in Figure 2 below. (Figure 2 is a of a single practical dipole radiator. Please note there is no appreciable field along the array axis)

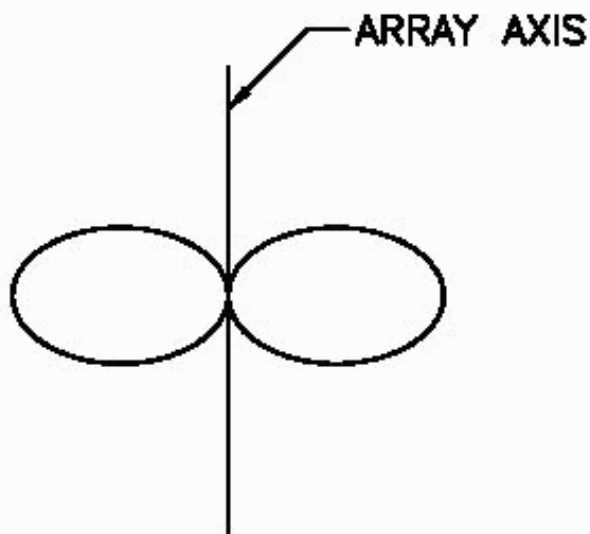


Figure 2

Antenna Elevation Patterns

Most antennas have vertical spacing of 1 wavelength (λ) between vertical elements. We will first look at the slot antenna, which is the most popular antenna type currently in North America.

Another popular antenna is the VHF batwing antenna. The base design of the antenna is also 1 wavelength. A new version of the batwing antenna with 0.875 wavelength was introduced a few years ago to reduce RFR at short tower sites.

VHF panel and FM antennas are normally spaced at 1 wavelength, with many versions of antennas using 0.75, and 0.5 wavelength spacing,



Some Useful Terms

Beam Tilt The amount of tilt in degrees that the main lobe is tilted downward by electrically short spacing the top elements of the array, or by mechanically tilting the antenna downward. Electrical and Mechanical beam tilt can be used at the same time to increase the over all depression of the main lobe

Null Fill The amount of field that is added between the main lobe and the first and/or second secondary lobes. Null fill keeps the field values from going to zero close to the main beam. Values of 5 to 20% are common and are added by short spacing the top elements of the array.

Beam Sway The difference in relative field over the bandwidth of the antenna. At a given depression angle of let's say -10 degrees, the field value of the low end the operating band is 0.16 of full field and at the top end of the band it's 0.19 of full field – thus giving you a beam sway of 0.03 of peak field (or signal level) across the band.



SLOT ANTENNA BASICS

DESIGN OF A STANDARD SLOT ANTENNA

Arranged in an array, and placing the individual elements such that their unit radiated field maxima align with the broadside array field maxima when placed in a linear array such as is shown in Figure Five 3, a practical and useful linear array antenna results.

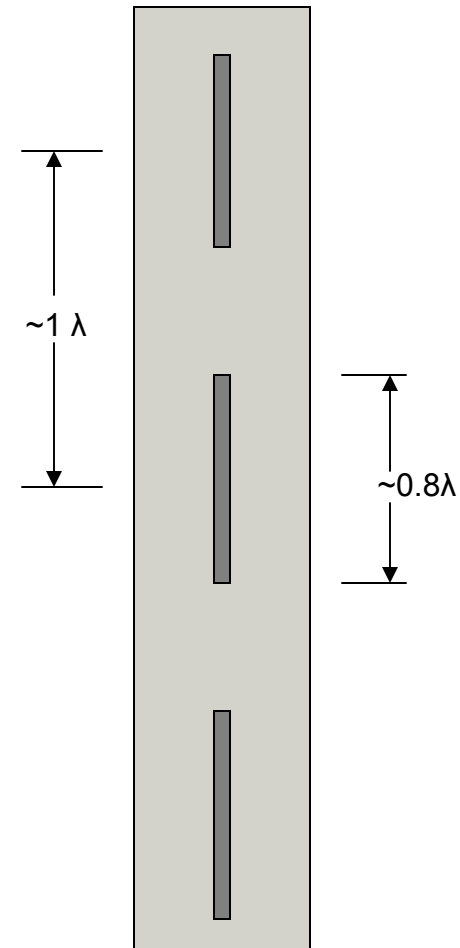
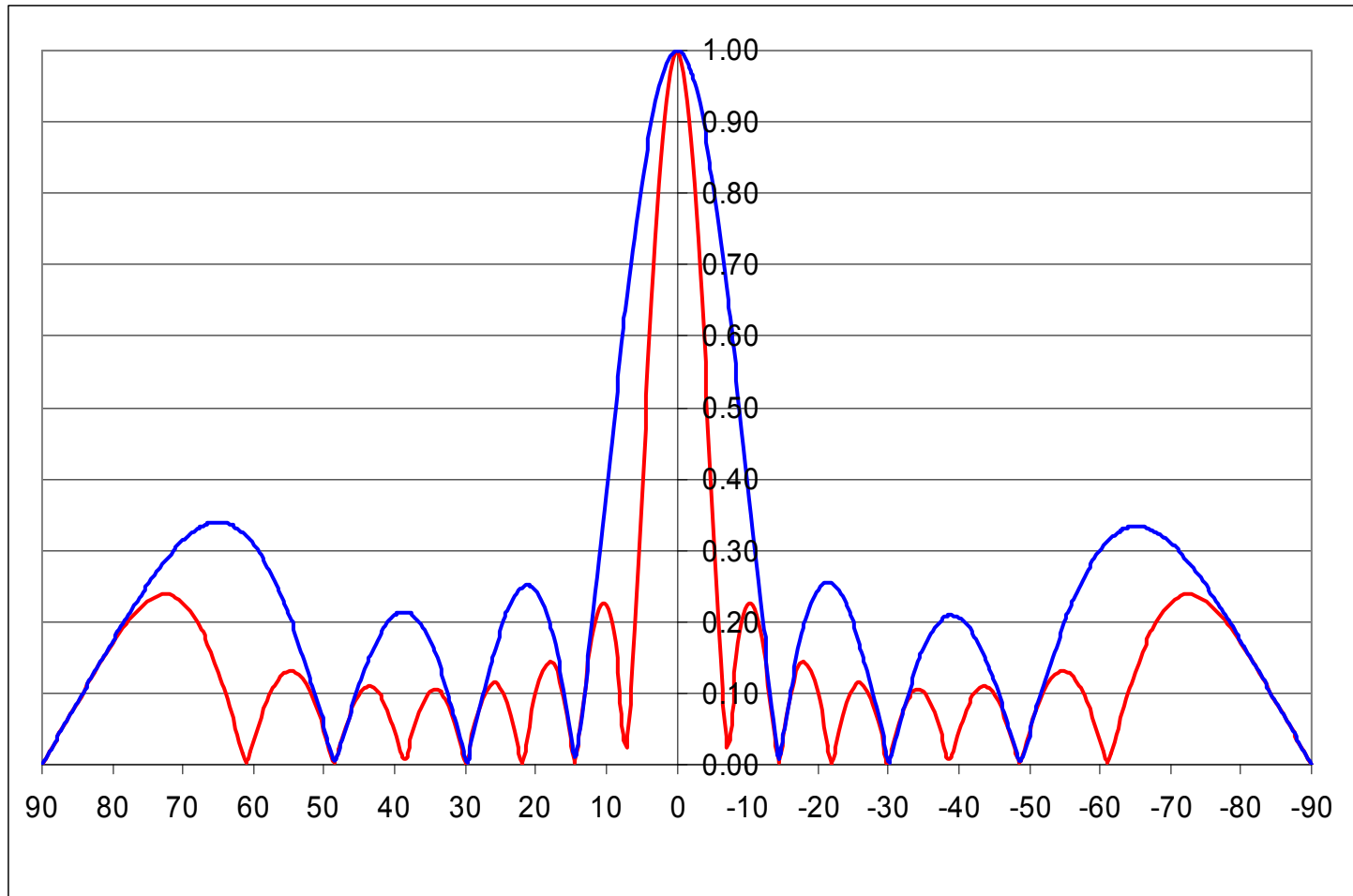
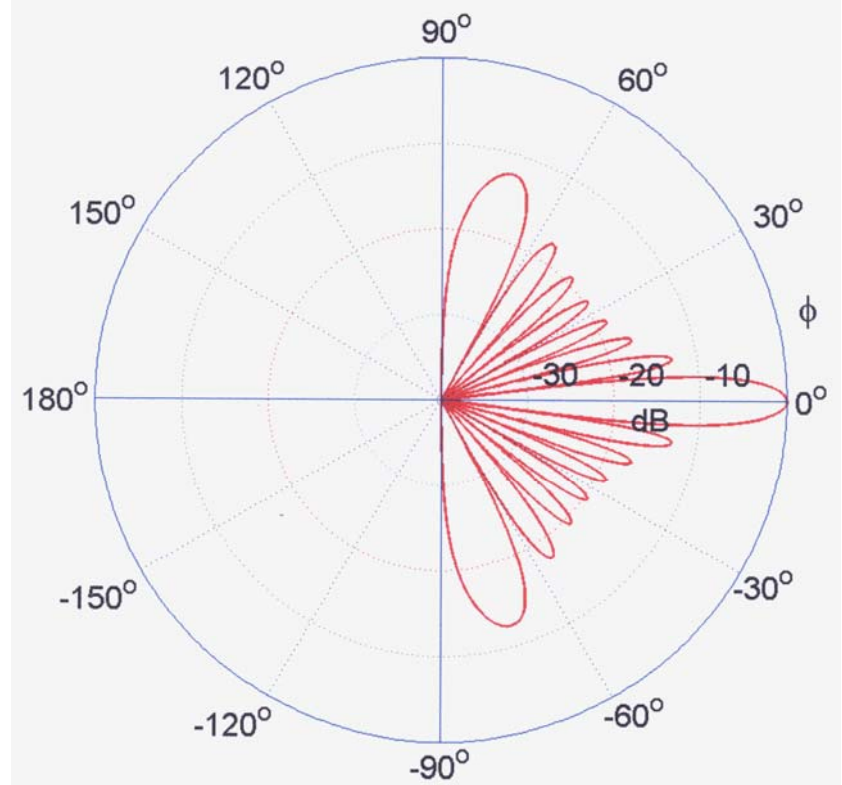
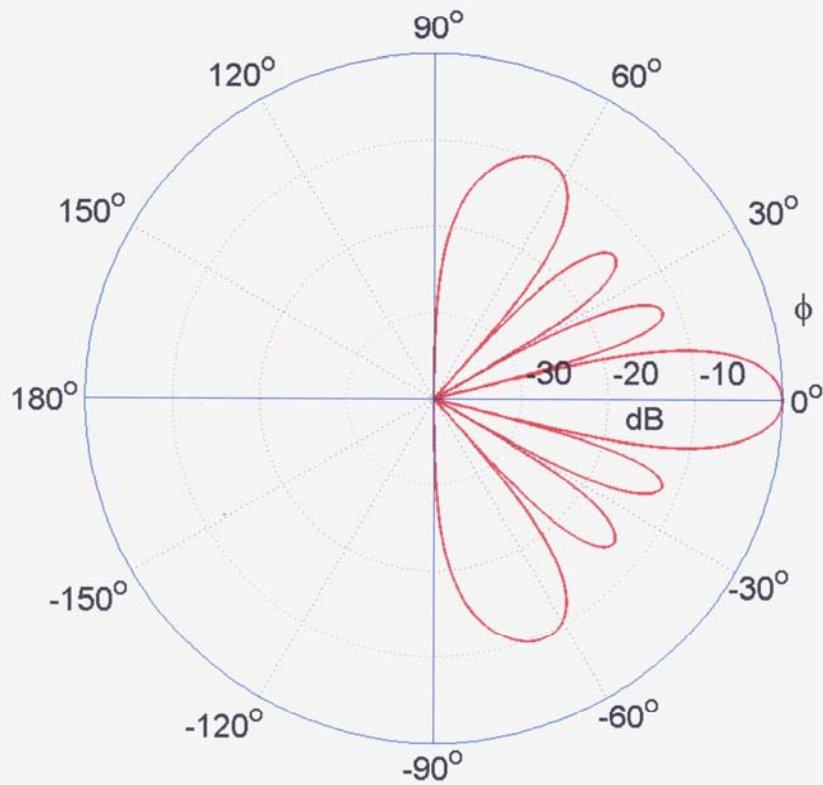


Figure 3

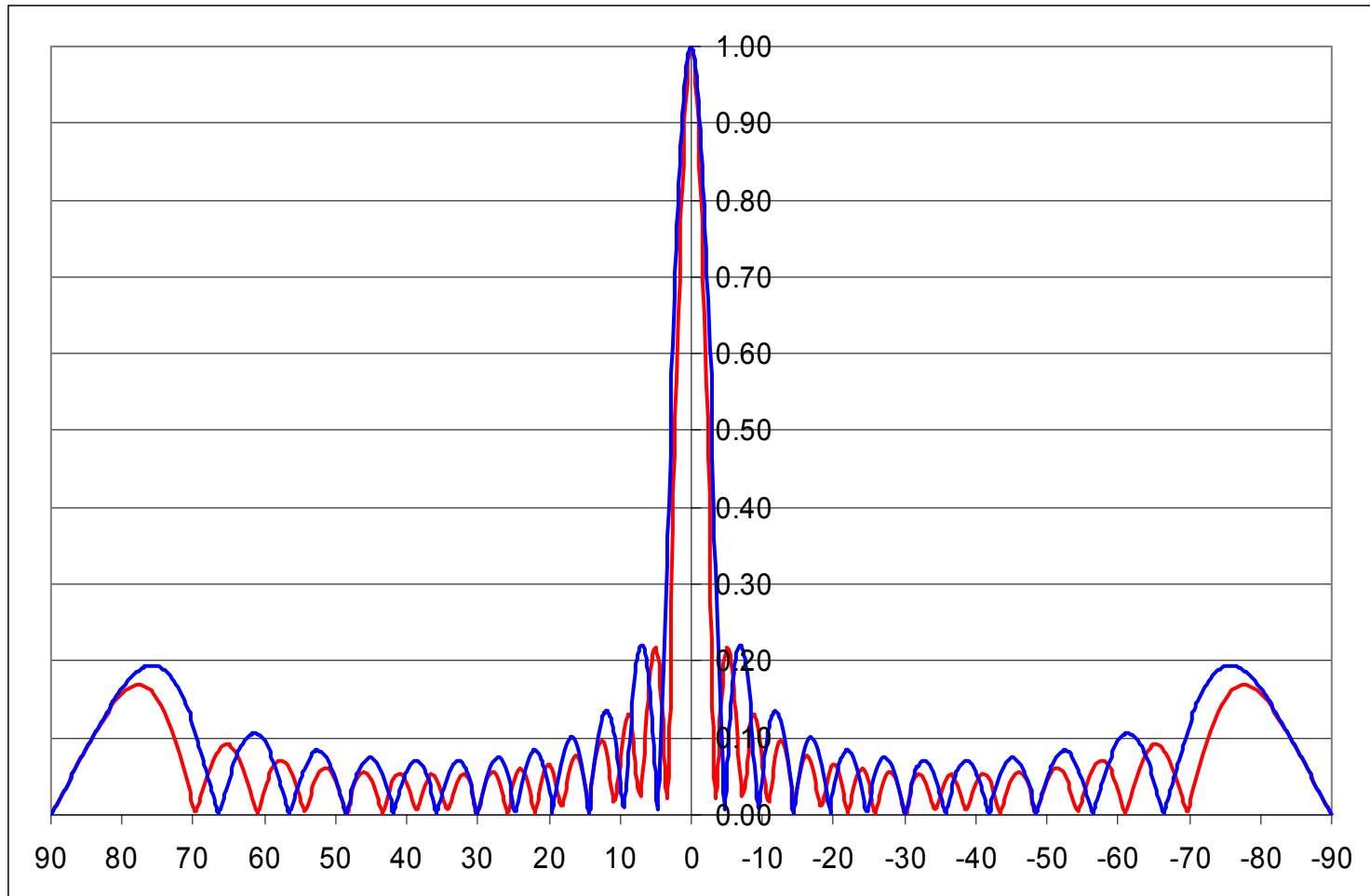




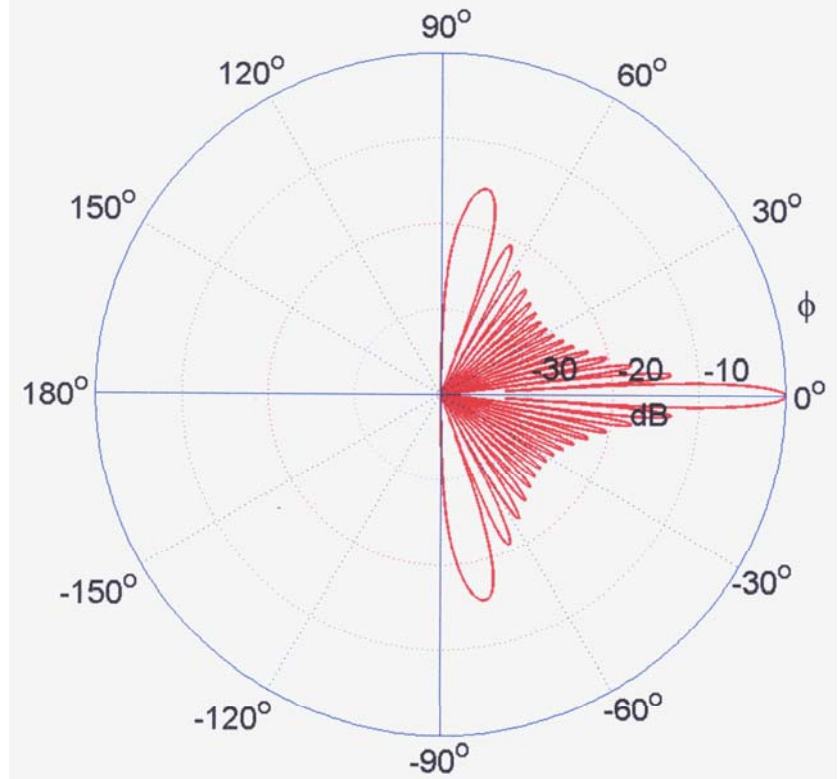
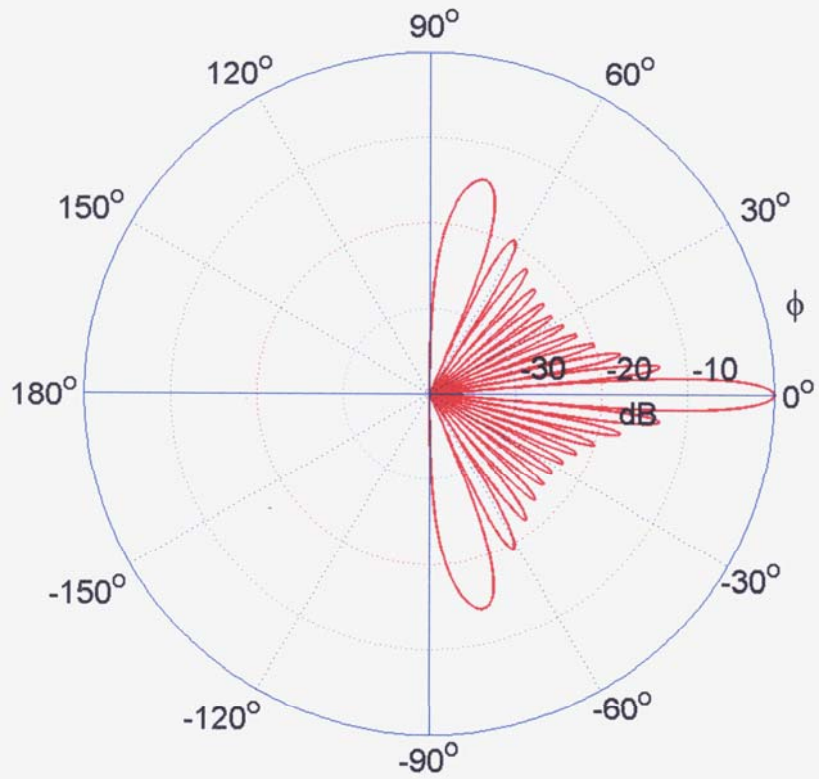
A Cartesian plot of a 4 bay and 8 bay one wavelength spaced antenna. These elevation patterns have no beam tilt or null fill.



Here are the same two elevation patterns, presented in polar form. The four bay pattern is on the left – the eight bay pattern is on the right. The Cartesian plots are linear percentage of peak field – the polar plots are in relative power. The scale of the polar graph is 40 dB.



A Cartesian plot of a 12 and 16 bay – one wavelength spaced antennas. Note the 16 bay pattern has a little null fill – but no beam tilt.



Here are the two same elevation patterns presented in polar form. The 12 bay is on the left – the 16 bay on the right.

Feed Systems for UHF Antennas

There are several feed system designs for antennas.

Panel and Batwing antennas are branch fed from a single or dual input. Larger UHF slot antennas can also be branch fed.

Dipole and slot antennas can also be end fed from the end of the array. This design is best used on short bay count antennas.

Longer slot antennas are usually center fed, or built up of multiple short bay sections.



Here is a center fed 8 bay UHF slot antenna. The input tee divides the power in two to feed the two 4 bay sections



Here is a branch fed UHF slot antenna. This is a 40 bay antenna. To minimize beam sway (which we will discuss next), the antenna is built as two center fed 20 bay (four 10 bay sections) antennas, with a branch feed system. This antenna could also have been built as 4 10 bay sections, fed from a 4 way power divider.

This antenna had a V.S.W.R. of less than 1:1.05 over the channel.

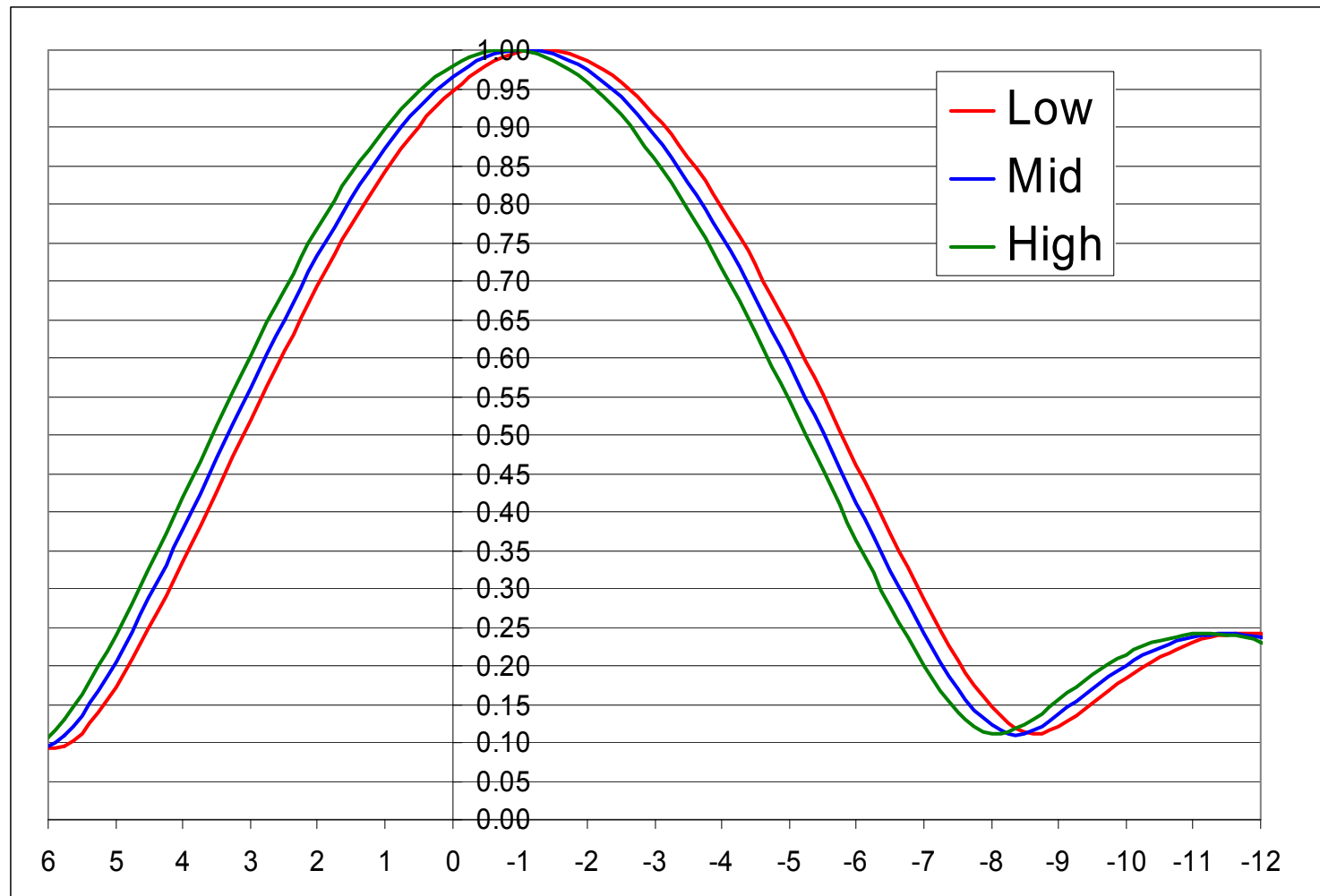
This is a 3 slot around omnidirectional antenna, and is 76 feet long.

Beam Sway

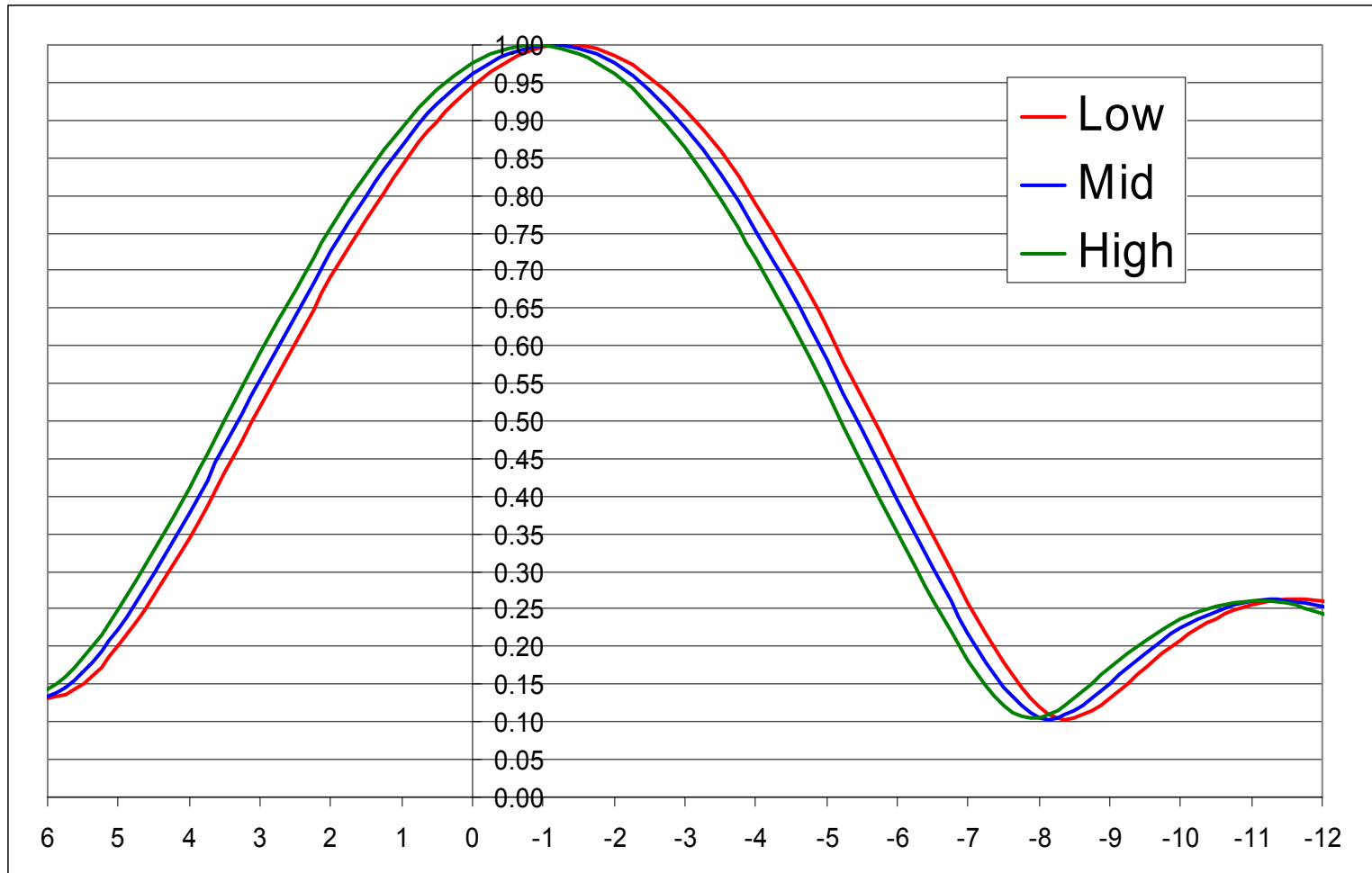
The next set of slides will compare beam sway of several antennas

- 8 Bay SFNstar™ End Fed Antenna
- 8 Bay SFNstar™ Center Fed Antenna
- 10 Bay SFNstar™ End Fed Antenna
- 10 Bay SFNstar™ Center Fed Antenna
- 12 Bay SFNstar™ Center Fed Antenna
- 16 Bay SFNstar™ Center Fed Antenna

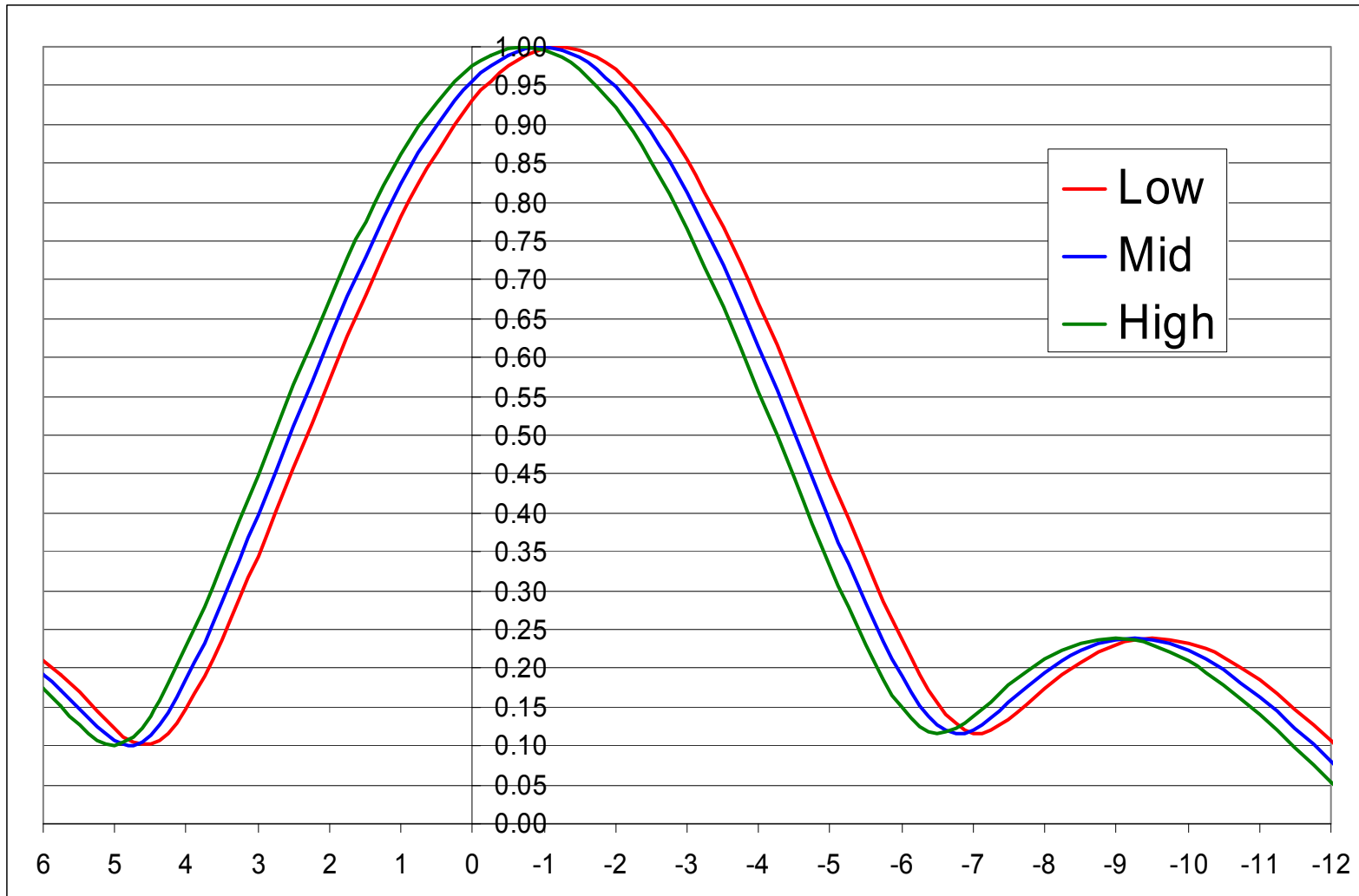
8 Bay End Fed SFNstar™ antenna beam sway plot



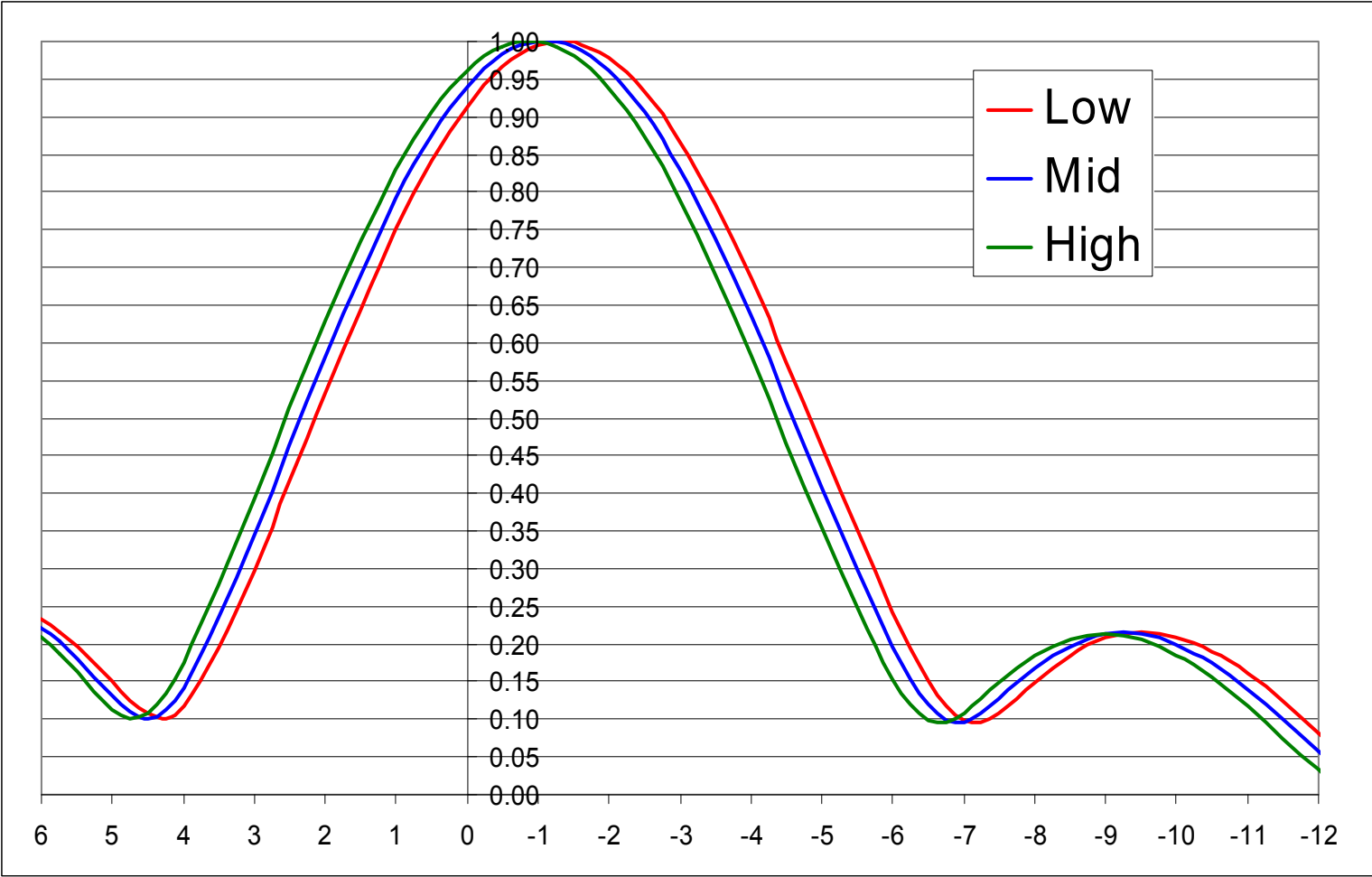
8 Bay Center Fed SFNstar™ antenna beam sway plot



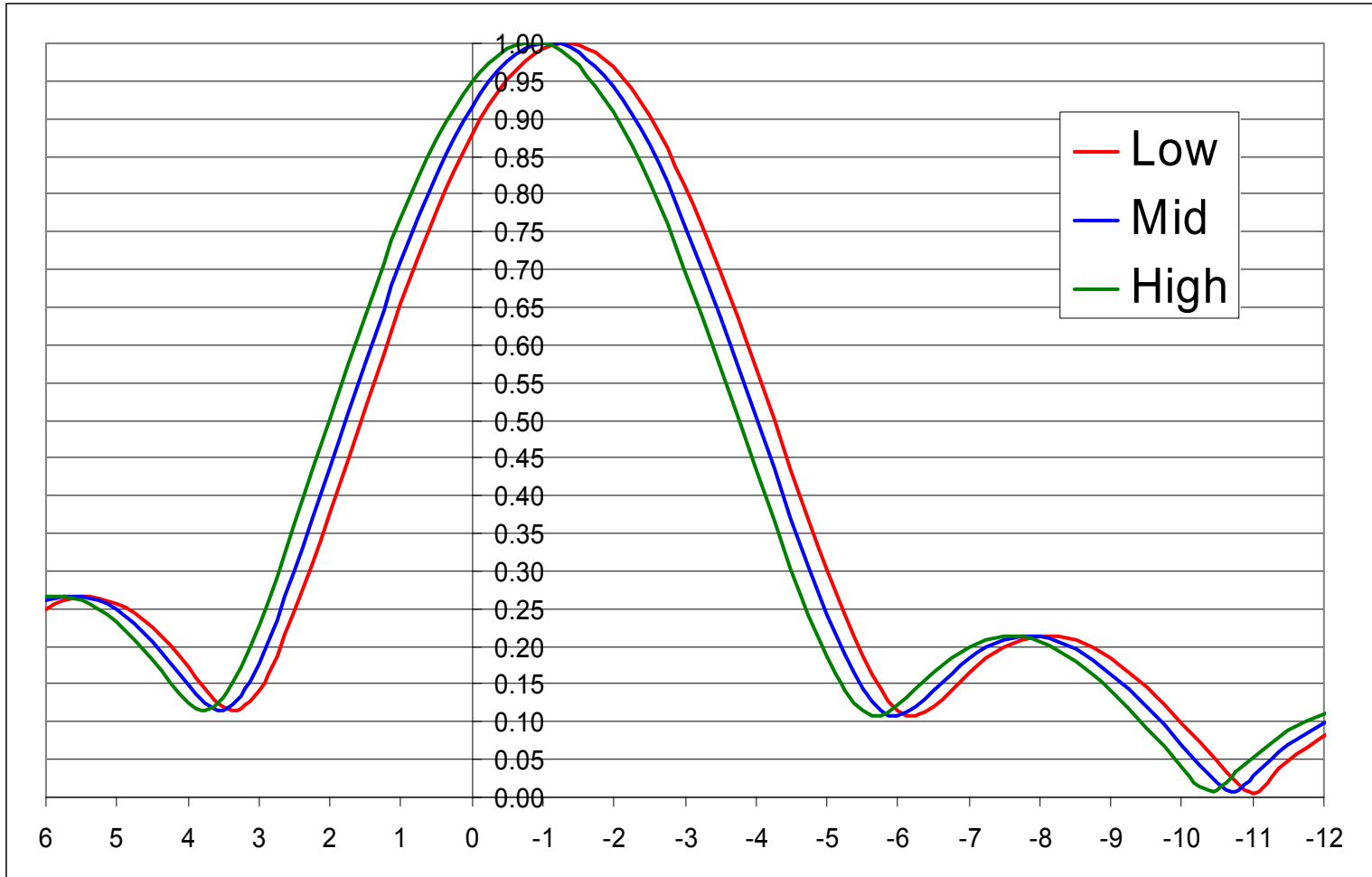
10 Bay End Fed SFNstar™ antenna beam sway plot



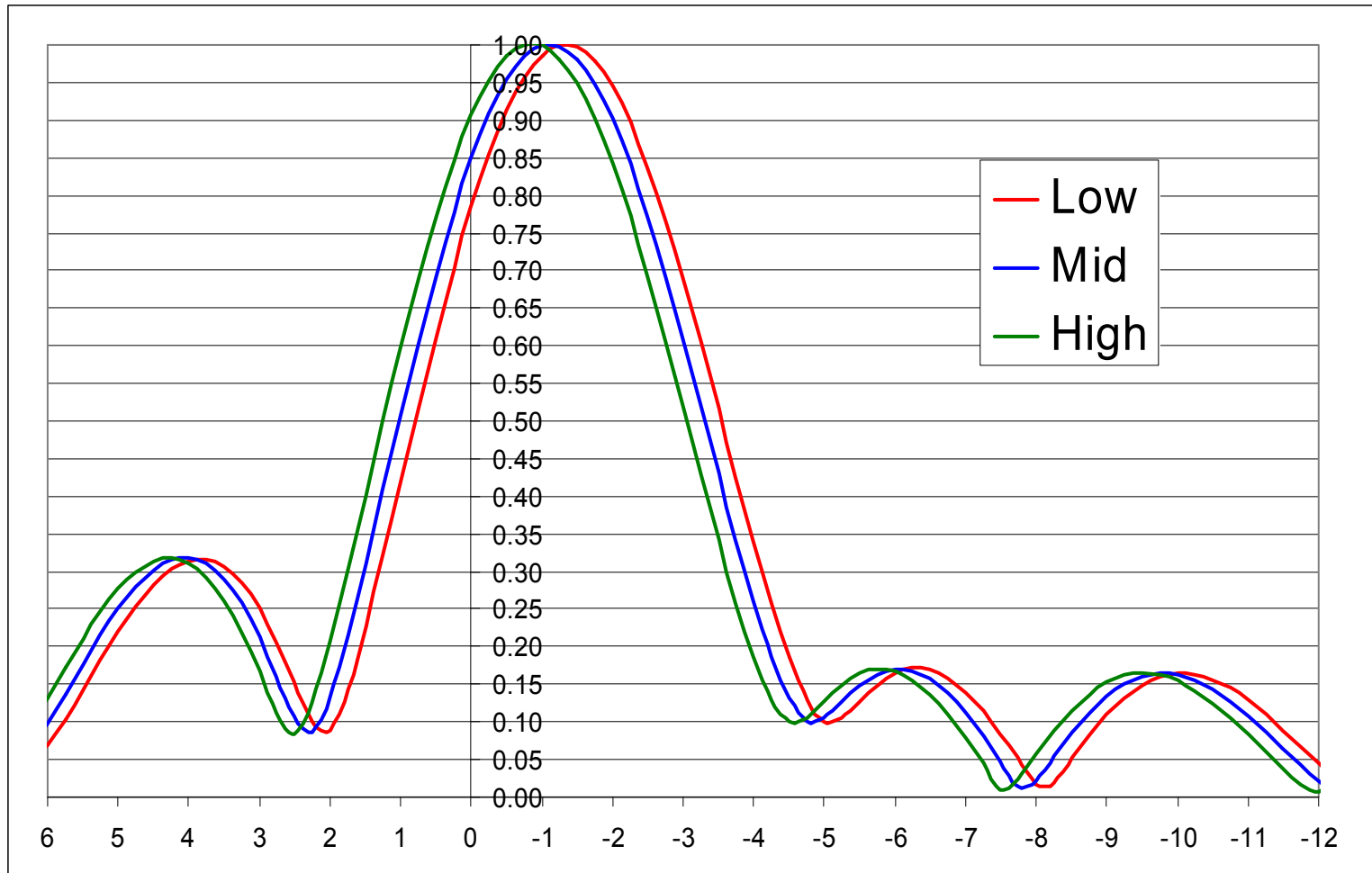
10 Bay Center Fed SFNstar™ antenna beam sway plot



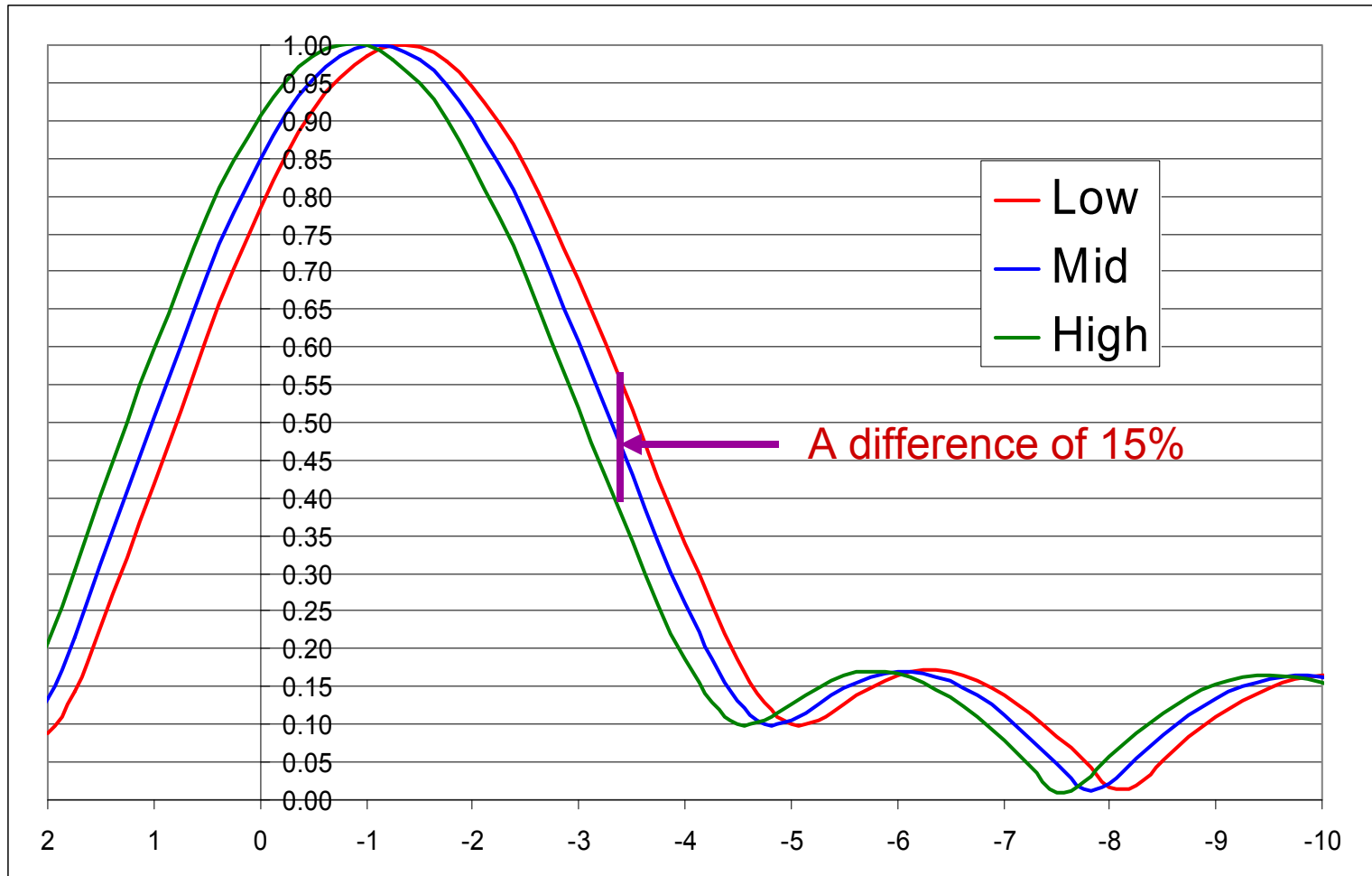
12 Bay Center Fed SFNstar™ antenna beam sway plot



16 Bay Center Fed SFNstar™ antenna beam sway plot



16 Bay Center Fed SFNstar™ antenna beam sway plot



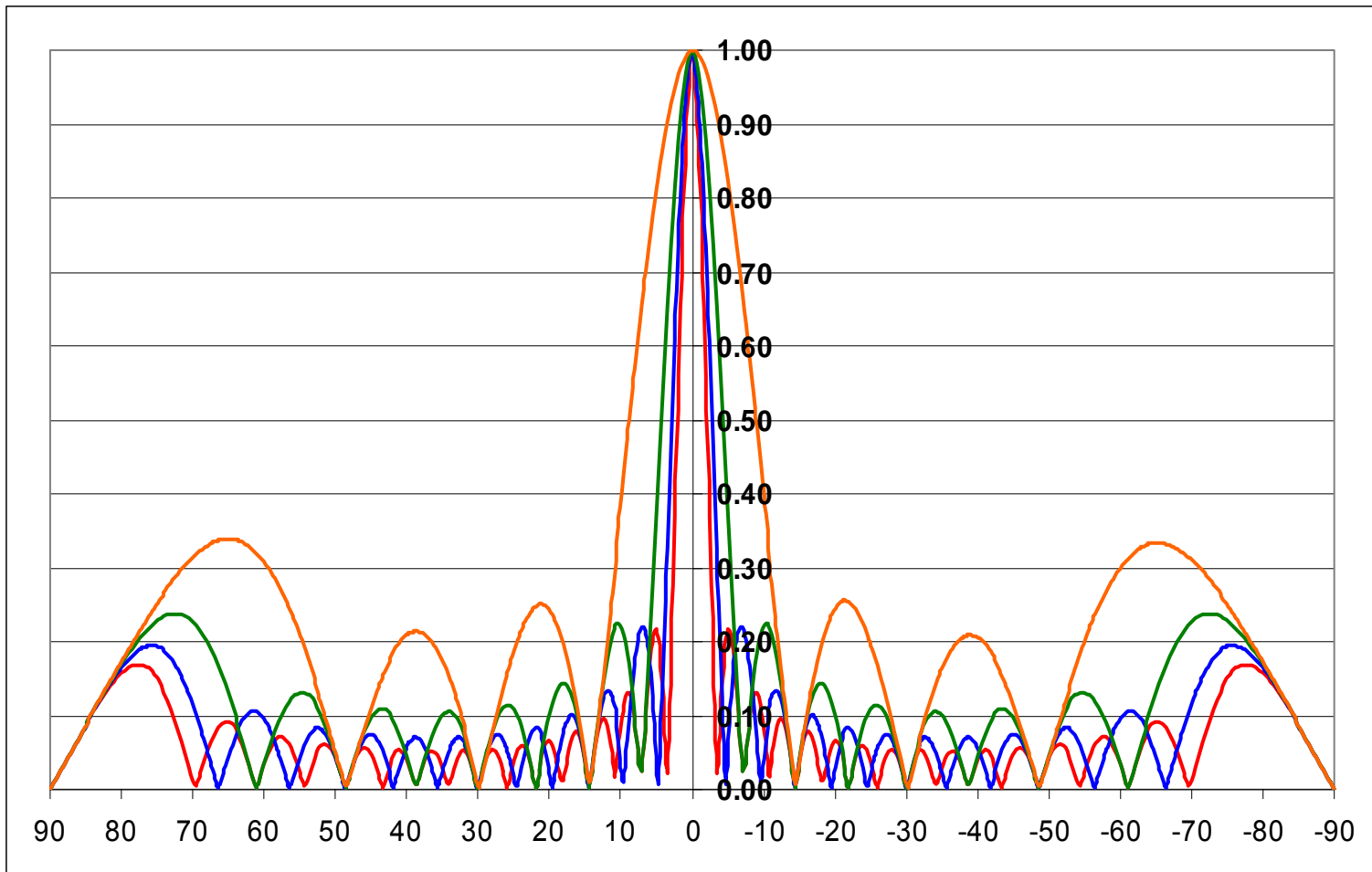
The 16 bay plot with an expanded scale – note the field value difference at -3.25 degrees

Designing Antennas to lower RFR

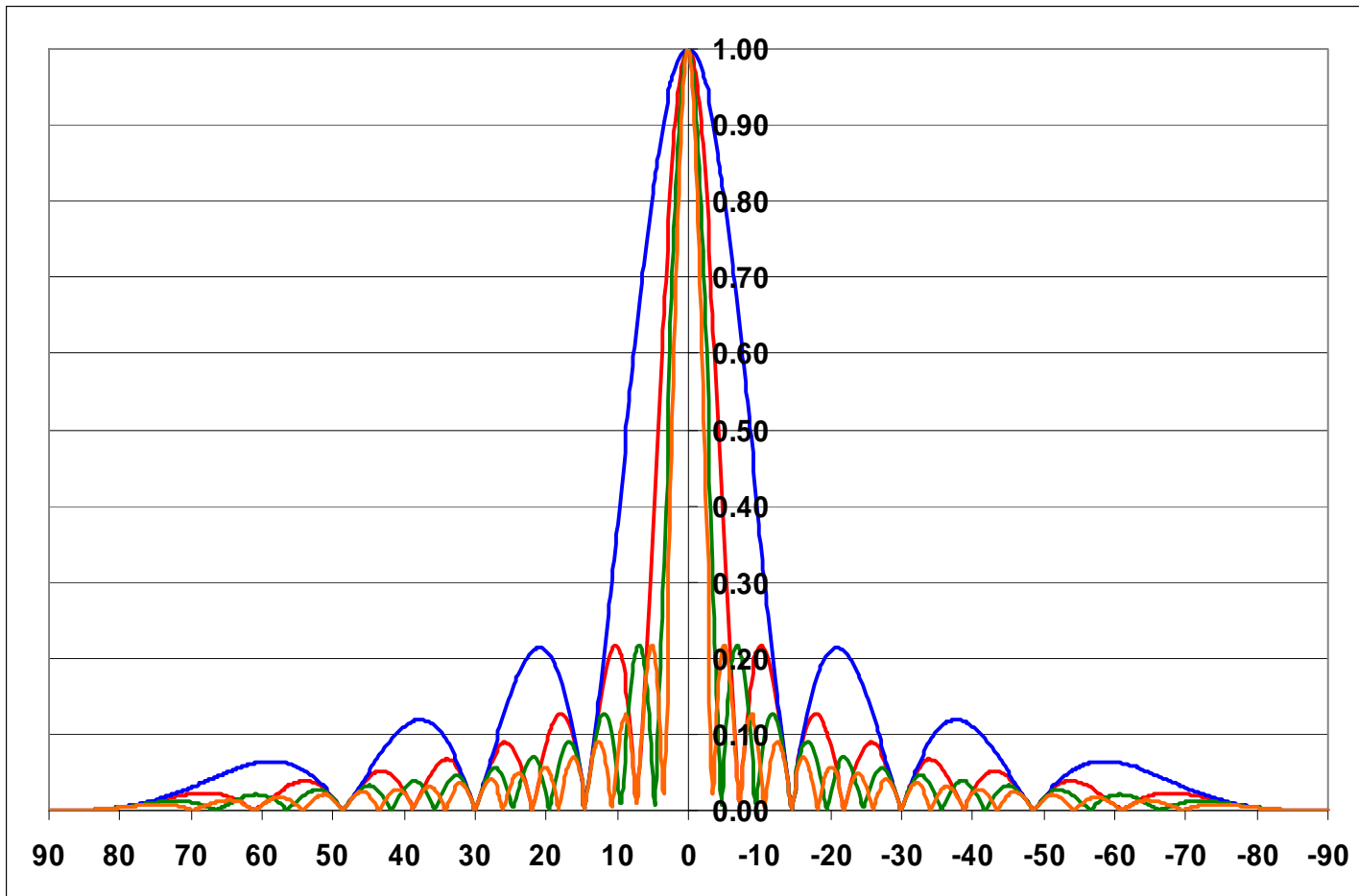
For broadcasters the perfect antenna would concentrate all of the radiation from the horizon to about 10 degrees below the horizon. In reality most antennas place a good deal of radiation at higher depression angles, and above the horizon.

On short tower or rooftop mounted sites, RFR can be a real problem. One problem with standard spaced (1 Wavelength) antennas is the residual grazing lobes at about +/- 80 degrees do not decrease with bigger bay count antennas. The last grazing lobe is usually the one to cause the worst RFR problem as you will see on the next slide.

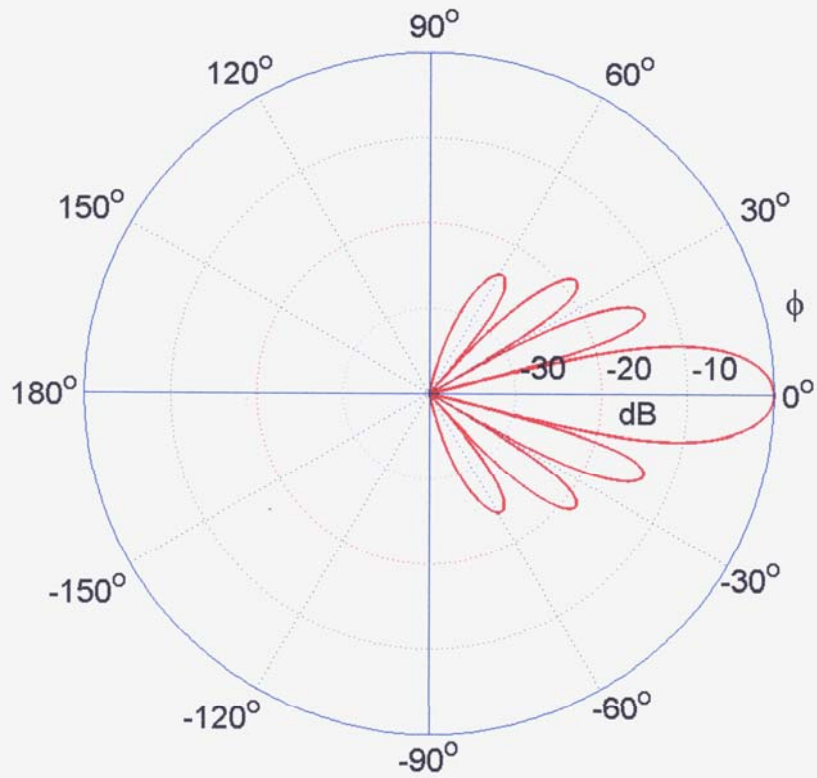




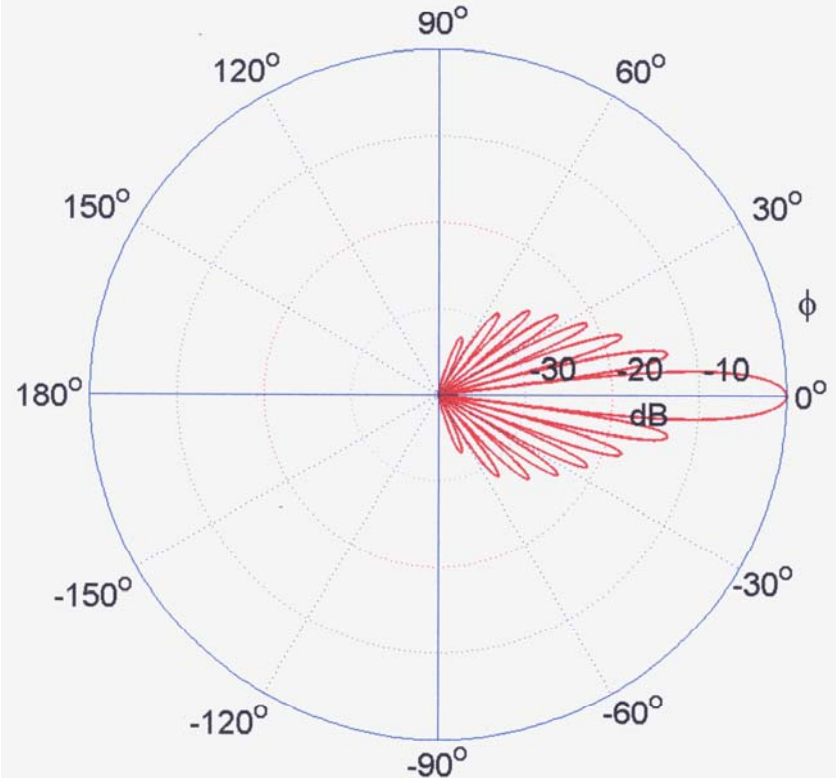
A Cartesian plot of a 4 bay antenna (ORANGE), 8 bay antenna (GREEN), 12 bay antenna (BLUE), and 16 bay antenna (RED). (Note the same relative field value at ~ -80 to -90 degrees for all antennas.) This example is valid for all 1 wavelength spaced antennas.



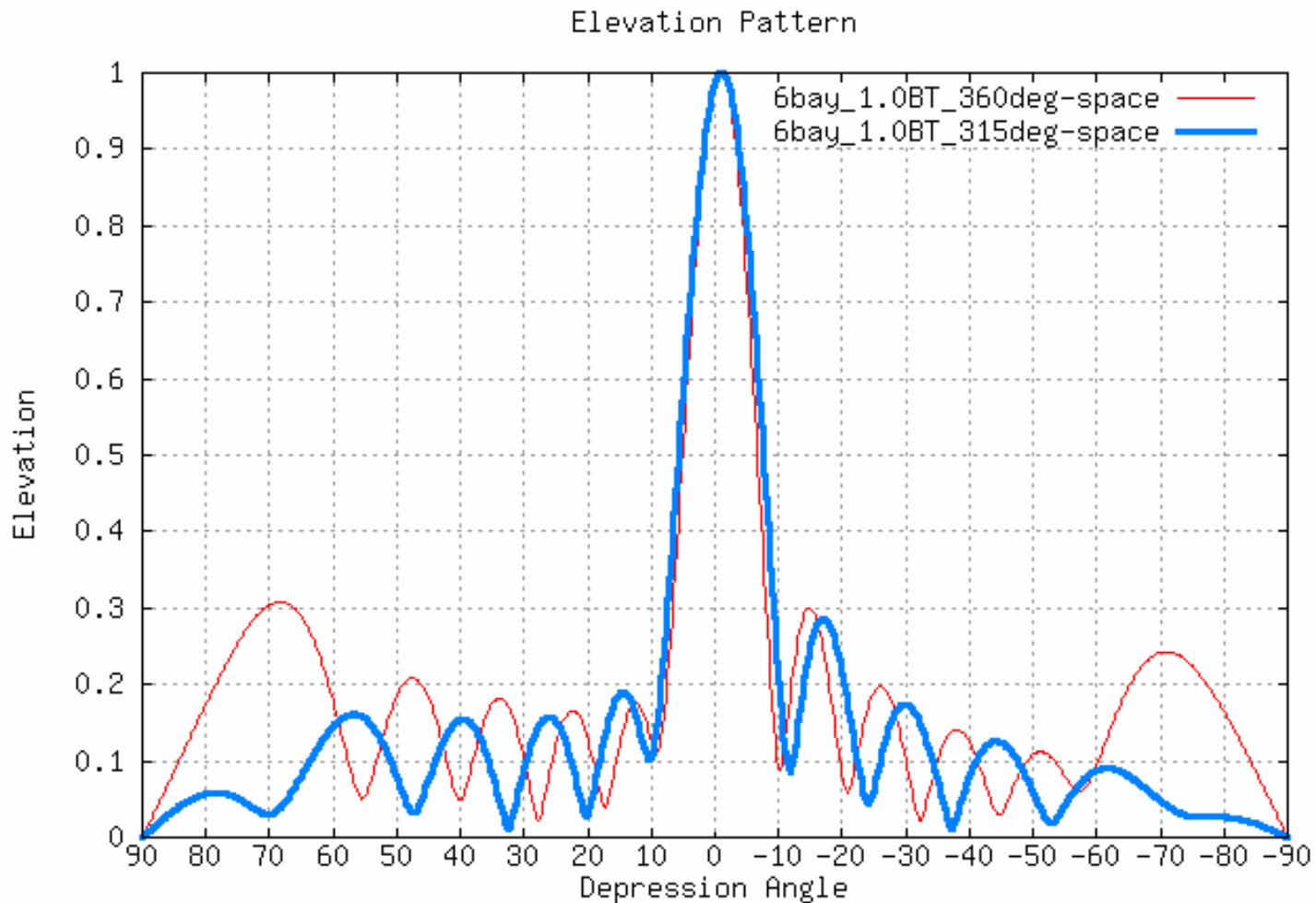
Cartesian plot of four SFNstar Antennas – the 4 bay is in **BLUE**, the 8 bay in **RED**, the 12 bay A in **GREEN**, the 16 bay is in **ORANGE**. Note the much smaller high axial angle grazing lobes on these antennas.



Polar plot of a 4-bay SFNstar™ antenna. The lowest “grazing lobe” is more than 24 dB below the main lobe.



Polar plot of an 8-bay SFNstar™ antenna. Here lowest “grazing lobe” is more than 33 dB below the main lobe.

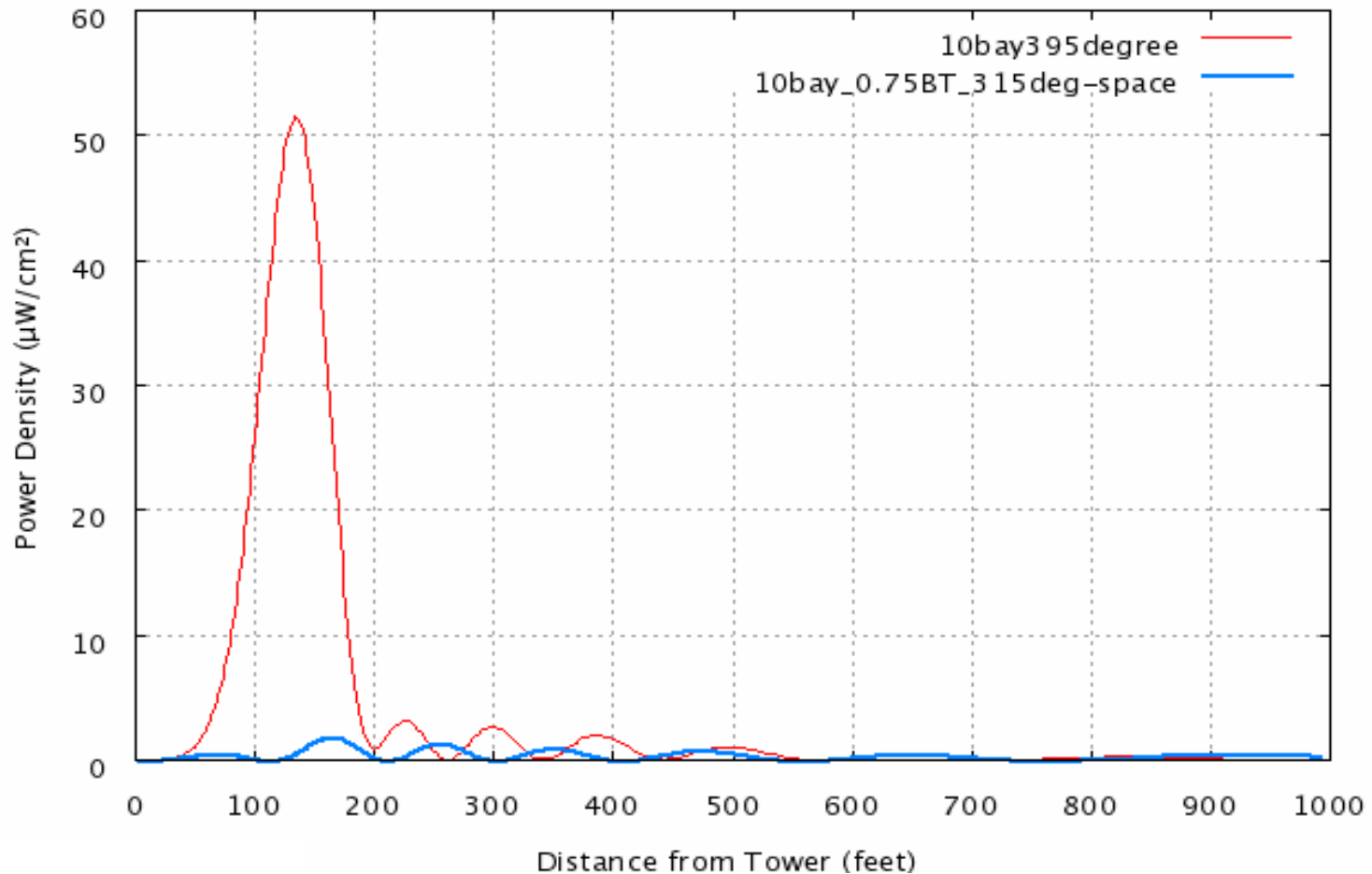


Here is a elevation plot of a 6 bay VHF antenna – the red plot is a 360 degree spaced antenna – the blue plot is a 315 degree spaced antenna

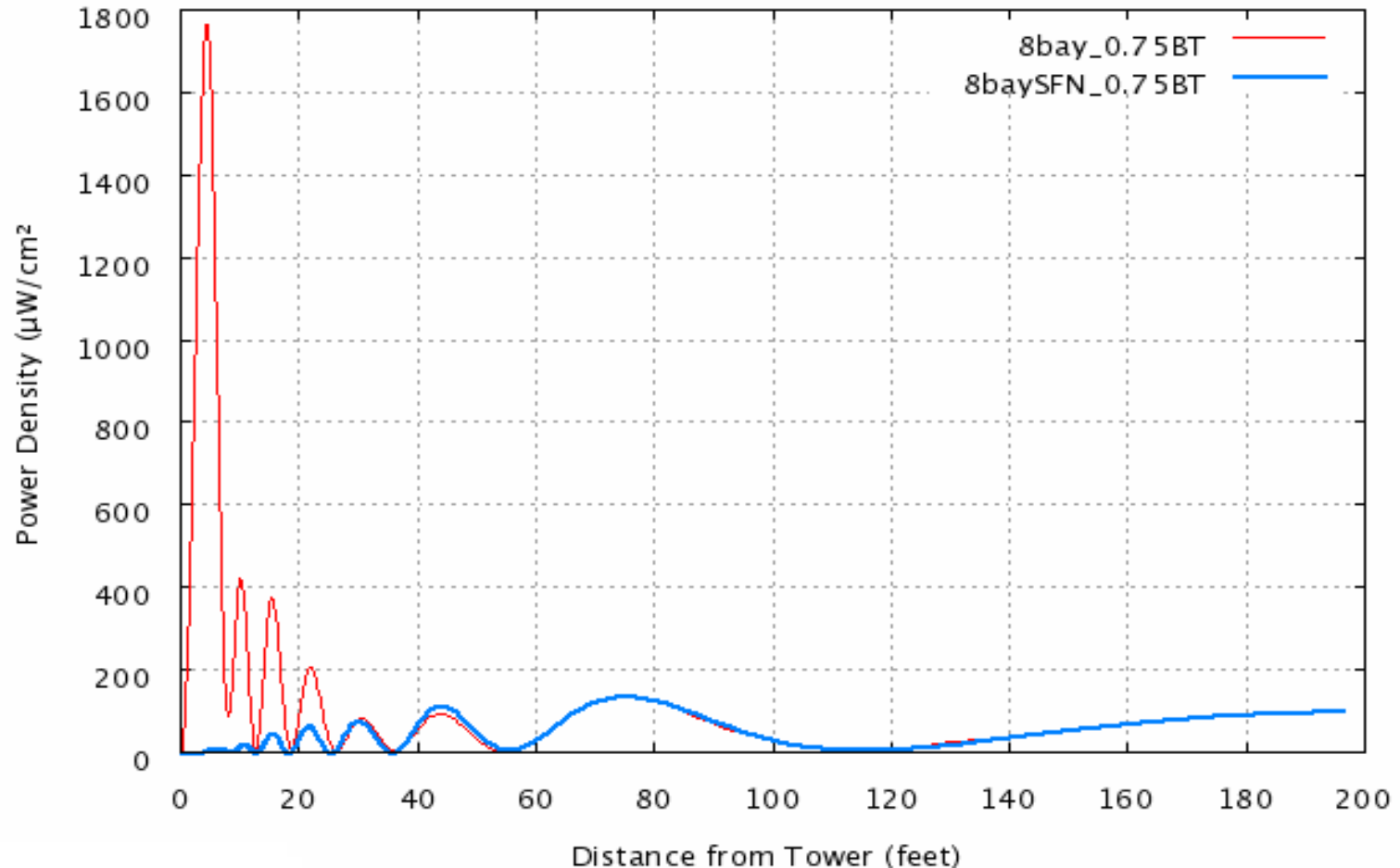
Where are the RFR hot spots ?

The next few slides will show you where the RFR hot spots are for a few sample antennas. We will look at both UHF and VHF applications.

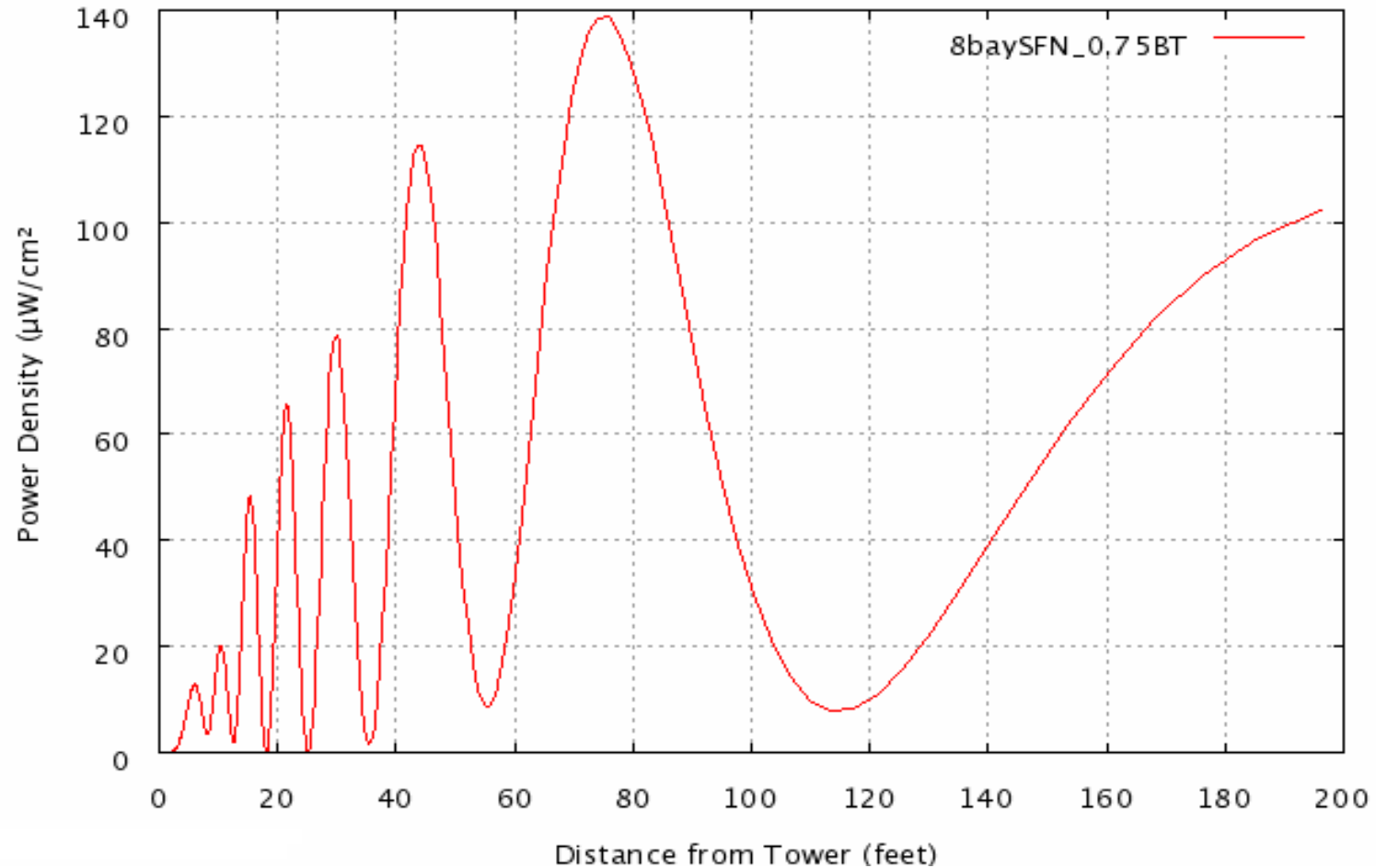
RFR Calculator



A power density plot of a 10 bay channel 11 standard batwing antenna (RED), versus a 10 bay optimally spaced batwing antenna (BLUE). ERP is 90 kW – height is 300 feet.

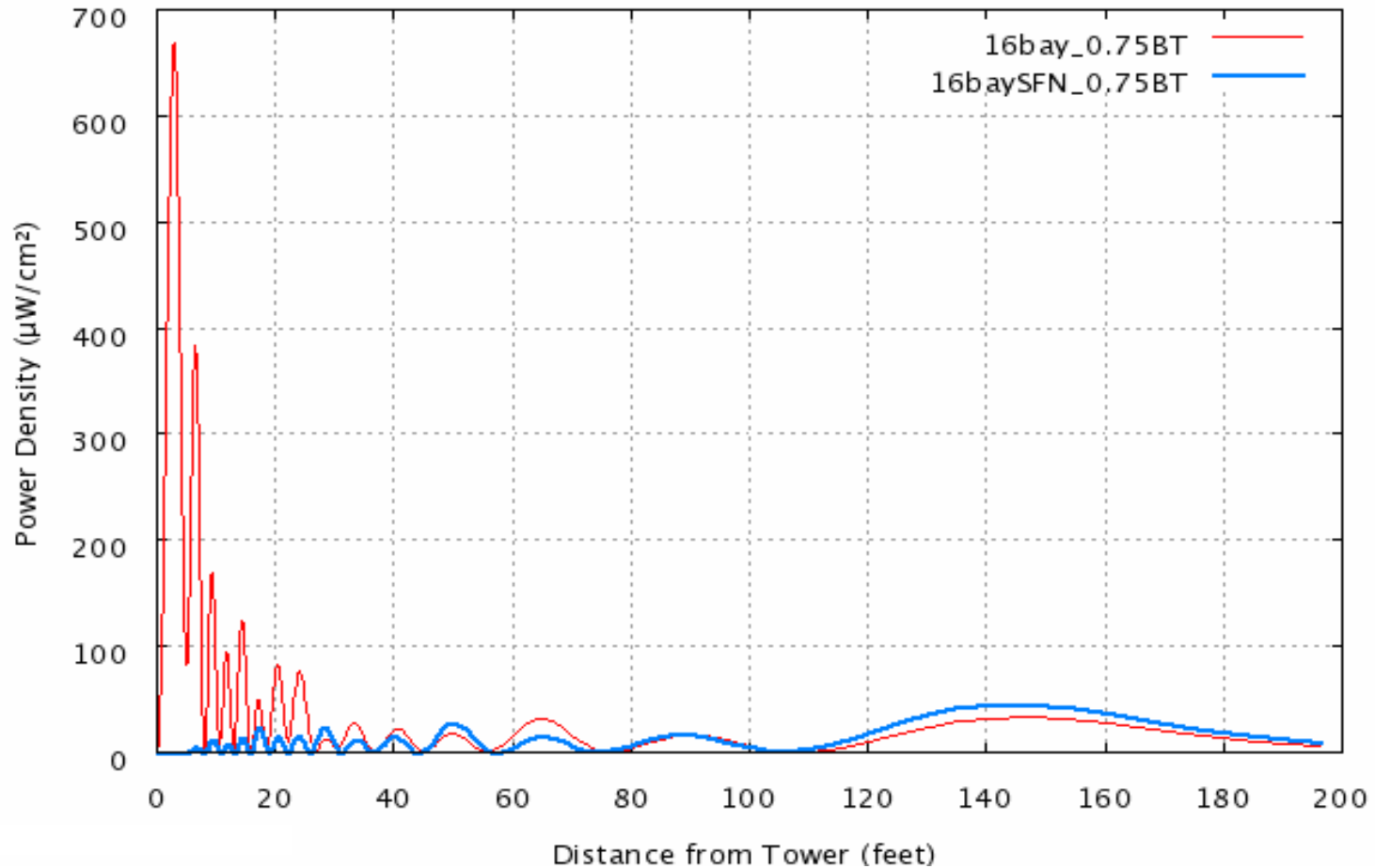


A power density plot of a 8 bay standard antenna, (RED), versus an 8 bay SFNstar antenna, (BLUE). (ERP: 30 kW; Height is 22 feet.)



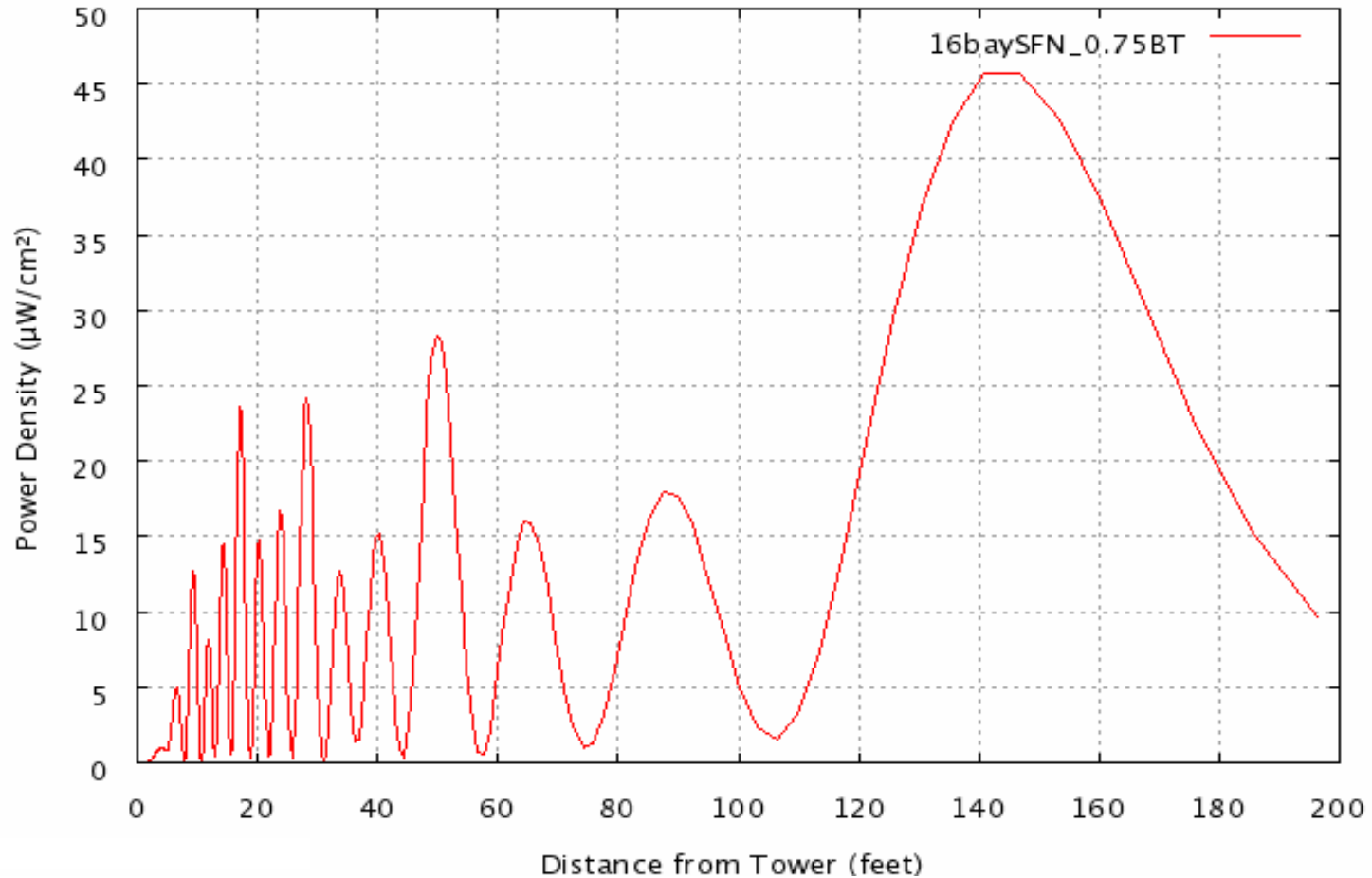
A plot of just the 8-bay SFNstar™ antenna. (Again, ERP: 30 kW; height above the measuring plane is 22 feet.)

RFR Calculator



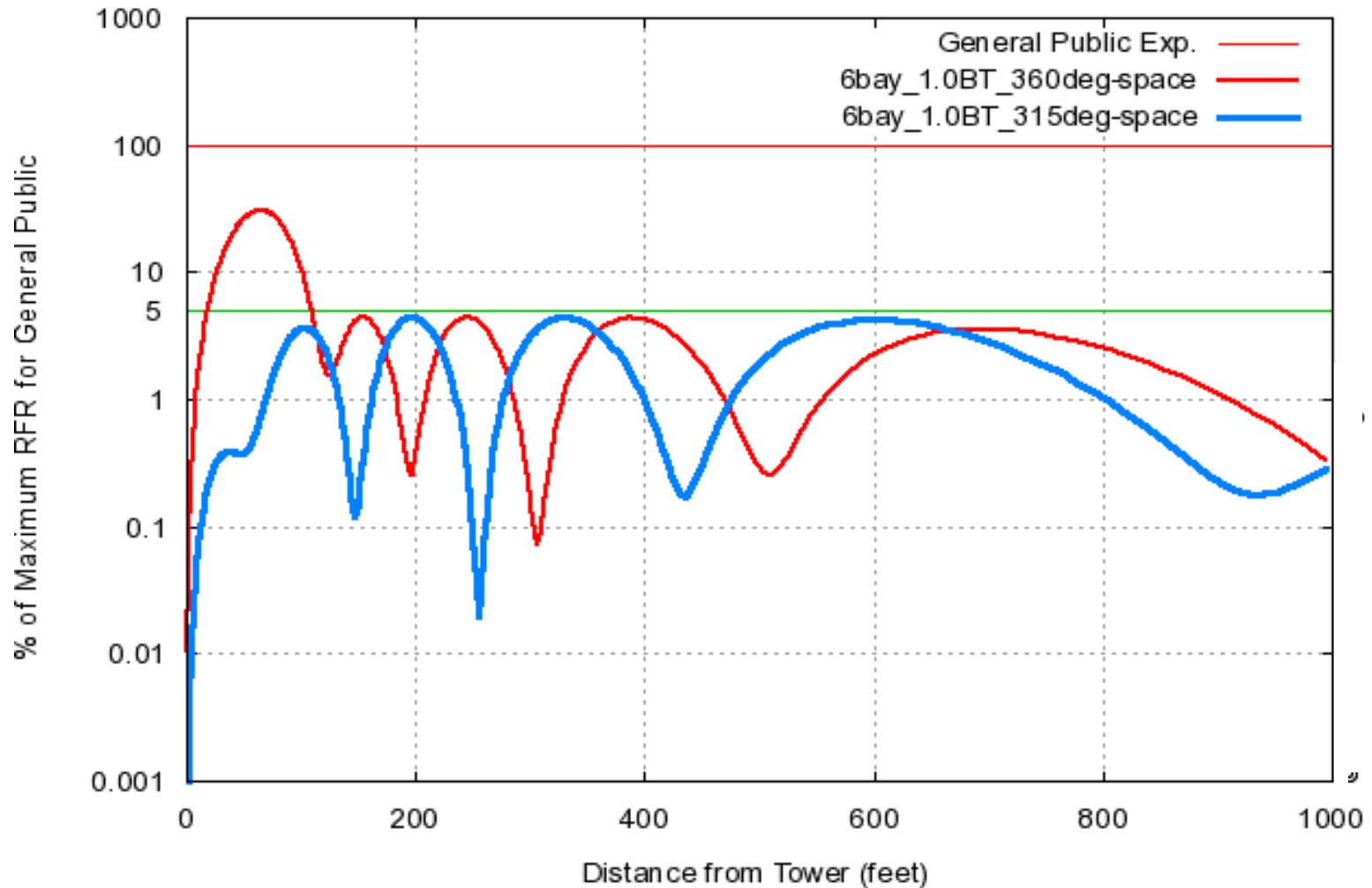
A power density plot of a 16-bay standard antenna (**RED**), versus a 16 bay SFNstar antenna, (**BLUE**). (ERP is 30 kW – height is 22 feet.)

RFR Calculator



A Power Density Plot of the 16 bay SFNstar Antenna alone. (ERP is 30 kW – height is 22 feet. Please notice the Units on the Power Density axis.)

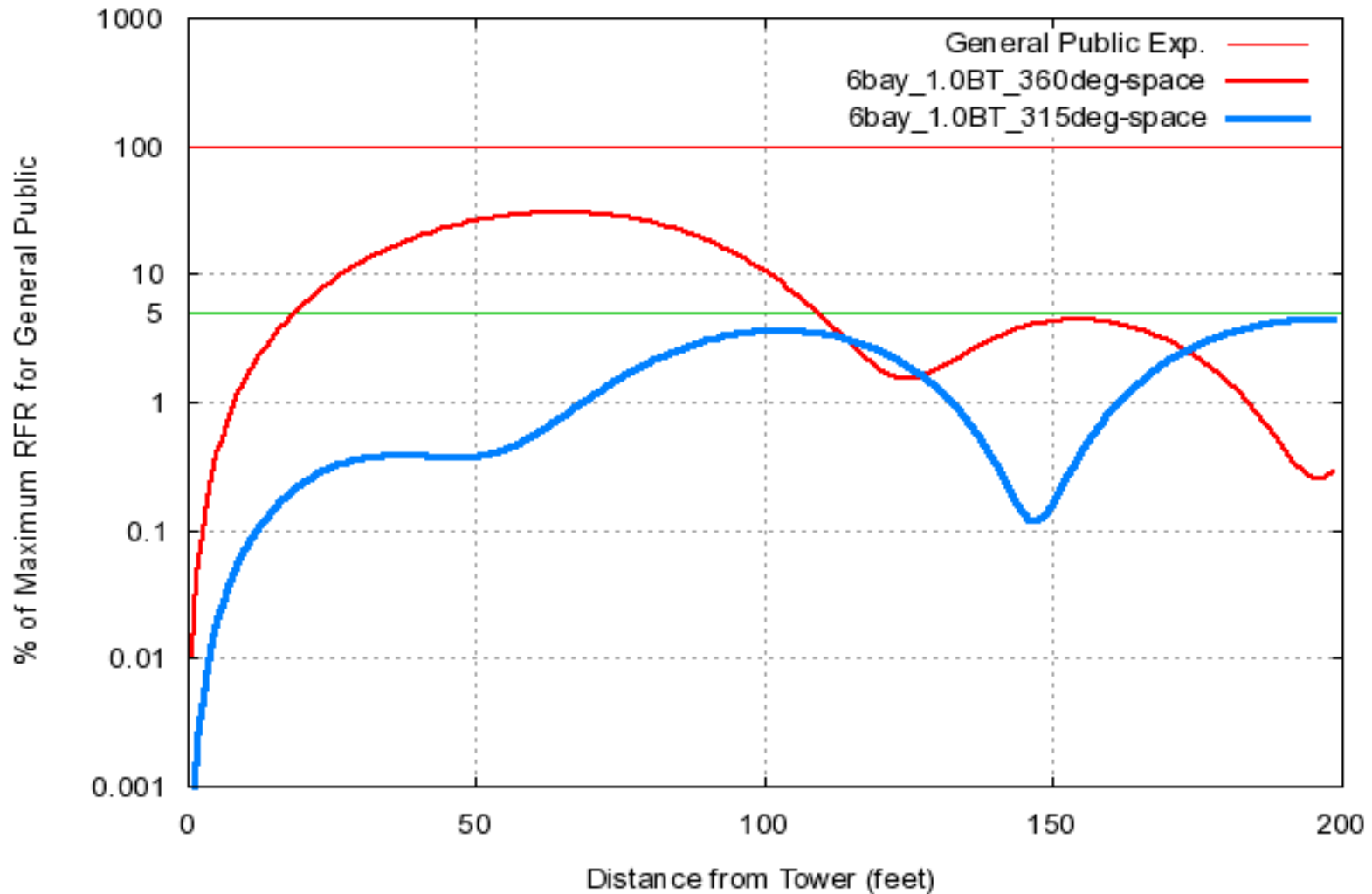
MPE Calculated at 75 kW – 200 feet FCC OET 65 Reflection coefficient applied



Here is a RFR plot of 6 bay antennas 200 feet up with an ERP of 75 kW - the red plot is a standard spaced antenna – the blue is a 315 degree spaced antenna



MPE Calculated at 75 kW – 200 feet FCC OET 65 Reflection coefficient applied



Here is a expanded view of the last slide with a 200 foot scale

Questions ? Contact Information

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